SCIENCE FOR SECONDARY SCHOOLS

LIFE SCIENCES

Classes IX—X

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CLASSES IX—X

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FOREWORD

The National Policy on Education adopted by the Government of India recommended that Science and Mathematics should form an integral part of general education till the end of the Secondary School stage. Accordingly, the Department of Education in Science and Mathematics of the National Council of Educational Research and Training, developed the syllabi and textbooks for Classes IX–X as part of its continuing programme of textbook preparation for which the existing middle school textual materials in science were taken as the base. These materials were developed through workshops involving school teachers and subject experts and published by NCERT in May 1975. The Central Board of Secondary Education adopted these textbooks from the 1975 academic session.

The profile of the new pattern of school education at a national level was projected in a document, 'The Curriculum for the Ten Year School--A Framework' (NCERT 1975). In order to translate into action the philosophy and objectives of the above national document, the Council constituted the Editorial Boards to develop textual materials in different school subjects. The Editorial boards consisted of eminent subject experts drawn from different parts of the country. While developing the syllabi and textbooks, the Editorial Boards kept in view the general guideline that the science curriculum should be related to everyday life and needs of the people with a view to making it a vital instrument for social change.

The Editorial Boards in science critically examined the existing syllabi and textbooks. Also, the Boards considered the available feedback from subject experts, practising teachers and teacher-participants of different orientation programmes.

The science content at this level has been developed unitwise and is visualised as a package, comprising physics, chemistry and life sciences The total package is intended to be a four-semester science course for Classes IX and X.

In view of the overall burden on the pupils the content coverage in the proposed science textbooks has been reduced as far as possible and the approach has been made more meaningful in the sense that the teaching-learning in science is not dependent upon sophisticated laboratory and equipment.

Despite today's technological advancement man is still confronted with the problems of environment, energy, population, nutrition and health, the solutions to which primarily rest on different areas of life sciences. In the present book some attempts have been made to make the pupils aware of these problems, to enthuse them to think and take right action to solve these basic problems of mankind in our national context.

Considering the available feedback received on the earlier book and the time constraint, the competent writing team under the guidance of the Editorial Board suitably reorganised and rewrote the earlier book to make it more simple and intelligible to the pupils. The book does not seek to provide readymade lessons, and, as such, teachers, using the book as a base, should plan their own lessons in order to provide the desired learning experience to the pupils.

The National Council is deeply indebted and grateful to the members of the Editorial Board, authors and others who have made this book possible. Comments on the book will be welcome for they will help us improve future editions.

RAIS AHMED
Director,
National Council of Educational
Research and Training.

New Delhi,
April 1977.

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UNIT—1

INTRODUCTION

CHAPTER 1

History and Scope of Life Sciences

1. The history of the study of life is as old as the history of mankind.
2. Biology has solved a number of human problems and is attempting to solve many more.
3. The study of biology is intimately associated with the knowledge of other branches of science
4. The science of biology is divided into a number of branches, each of which demands specialised study

BIOLOGY is *the science of living things* Like other branches of science, biology also started with man's curiosity about his surroundings. The early man was interested to know more about his body, both in health and sickness He observed growth, decay and death in the living world. His knowledge of different forms of life helped him to use different plants and animals for his food, shelter and clothing Today the knowledge of biology is used in the study of agriculture, medicine, sericulture, pisciculture and selective breeding of animals.

This kind of human interest in nature has existed since the earliest days of recorded history The writings of the Indian Ayurvedic physicians like Charaka and Sushruta of ancient India tell us many things about plants and animals. This knowledge was wholly practical Even in those early days man had knowledge of physiology and the anatomy of the human body.

Biology, as a branch of human knowledge, started with many observations made by the ancient Greek philosopher, Aristotle (384-322 B.C.). He is known as the father of biology. The term 'biology' was, however, first used much later by the French naturalist, Jean Lamarck (1744-1829) (Fig. 1.1).

After Aristotle little work was done in the field of biology. This was because very few people bothered themselves with scientific enquiries. The religious outlook was mainly responsible for this lack of scientific interest. Andreas Vesalius (1514-1564), a Belgian doctor, was the first to challenge the teachings of Aristotle. Till then, physicians blindly believed in what-

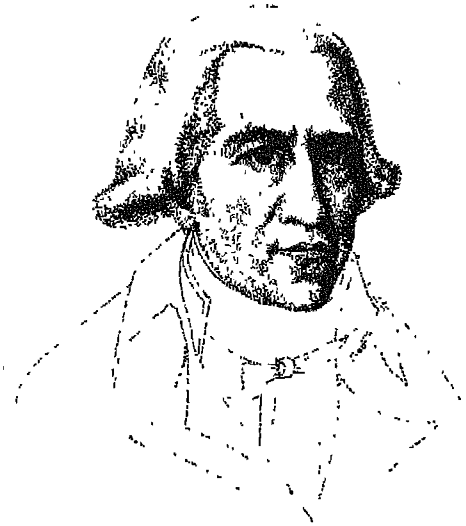


Fig. 1.1. Jean Lamarck

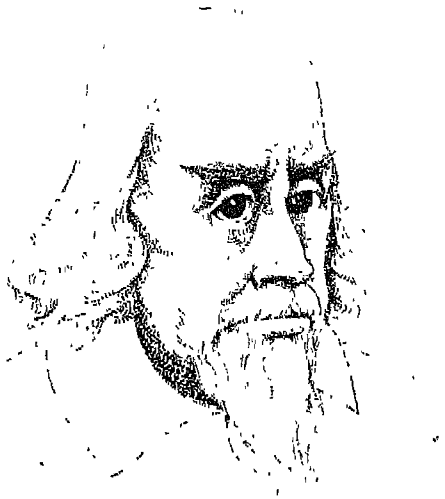


Fig. 1.2. William Harvey

ever was written by the doctors of the past. Vesalius dissected the dead bodies of men and animals to understand their inner structure. On the basis of this understanding, he challenged the teachings of Aristotle.

The English physiologist, William Harvey (1578-1657) (Fig 1.2), discovered the phenomenon of circulation of blood in the human body. This discovery led to a better understanding of the working of the human body.

Till the middle of the seventeenth century, the study of plants and animals was restricted only to observations with the naked eye. The life patterns of different plants and animals and their relationship were the major objects of the study. But the limitations of the naked eye did not permit man to understand living things more closely. Thus, the mysteries of life remained unknown.

The coming of new techniques and instruments helped the scientist to study living organisms in detail. After the invention of the lens and the microscope, Anton van Leeuwenhoek (1632-1723) (Fig. 1.3) and Robert Hooke (1635-1703) (Fig. 1.4) studied microscopic organisms and the internal structure of plants and animals.

The use of the microscope helped the scientist to study the nature of a cell, its constituent parts, cell division and other details of cell development. The electron microscope of today is a more powerful tool with which to look at and study even the subcellular units. As with all other sciences, the nature of the science of biology has been changing continuously. It started as a descriptive science, and the knowledge thus obtained was put to application. New problems came up and demanded experimentation. This led to the coming and use of new instruments and techniques. Today, biology

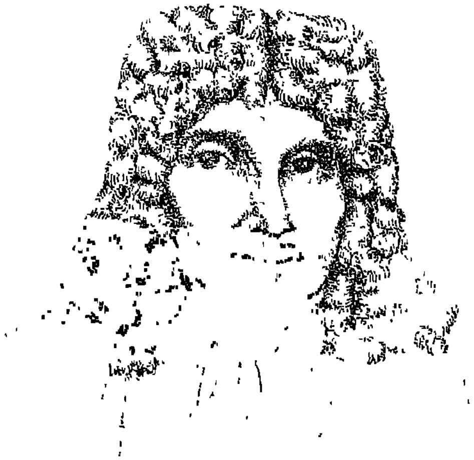


Fig 1.3. Anton van Leeuwenhoek

Fig 1.4. Robert Hooke

has acquired a multidisciplinary character It means that a knowledge of other sciences like physics and chemistry is necessary for biological studies Consequently, the biology of yesterday has evolved into what we call today the 'Life Sciences'.

WHY STUDY LIFE SCIENCES?

Man's place in the living world is unique because he is the only animals who has studied nature and has attempted to control his environment, he has solved a number of problems, but he has also created many. These problems are : radiation hazards, famine, over-population and diseases You may wonder how it is so The explosion of a nuclear weapon in any part of the world may cause great harm to all forms of life. It may produce slow and small alterations in organisms living over a very large area. Some of the effects caused by the radiation fallout may not be known immediately. Life scientists are trying to meet this challenge of radiation hazards. Scarcity of food, malnutrition and famine exist even today. The study of life sciences can help solve these problems. The study of life sciences is important for human life as it helps man to understand his own body and mind. In general, thus life sciences can be of tremendous use in human welfare. One of the examples worth mentioning is genetic engineering. Scientists are now attempting through genetic engineering to modulate the genetic material of man in order to cure him of genetically-caused disorders and to bring about improvements in the human race and its quality. Therefore, sociologically, life sciences will play a very important role in the near future.

One of the factors that can slow down the path of human progress is the over-population of human beings. Over-population has created a number of problems in the environment of man. It is adversely affecting the limited resources on which man lives Efforts are therefore, being made

1. to control the size of the human population
2. to find out ways for the welfare of man
3. to protect the environment from various kinds of pollution
4. to conserve, control and equitably distribute the available resources, so that they can be utilised by all for a longer period

To a large extent, modern science has succeeded in controlling a number of diseases But many diseases are yet unconquered Heart disease, cancer, allergy and viral diseases are some of these

In addition to what has been mentioned above, life scientists are trying to solve numerous other problems like the following How do the genes operate to control the individual human characteristics? How are the various life processes carried out? How did life originate on the earth? These are a few of the many questions which the scientists are trying to answer

THE SCIENCE OF LIFE — ITS PLACE AMONG OTHER SCIENCES

Today, life cannot be studied in isolation. Life science is closely linked with other sciences like physics, chemistry and mathematics.

It is worthwhile to get a clear picture of this interplay of the sciences You learnt earlier how water is absorbed by root hairs. It is by *osmosis* Osmosis is a physical phenomenon, exhibited by liquids when separated by a partially permeable membrane. Recall the simple experiment conducted in the earlier course in biology To understand the result of this experiment you should know the laws of diffusion of liquids and the properties of membranes. You use solutions in the experiment and so you have to know the basic properties of such solutions

You have also learnt something about the human body Examine what happens when you lift a weight with your hand Do you think that it has something to do with the systems of levers studied by you in the physics course?

Living beings, like any other object, are built up of matter. The study of matter is dealt with in chemistry and physics The fundamental substance of all living beings is *protoplasm.* Protoplasm in the living state contains a variety of organic molecules such as proteins, carbohydrates, vitamins, fats, and other molecules The modern trend is to study the chemical processes taking place in an organism The study of the digestive system, the circulatory system and the excretory system in man tells us how important the knowledge of chemistry is to understand the working of these systems in a better way.

ASPECTS OF LIFE SCIENCES

Botany and zoology are the major subdivisions of biology. A later addition is microbiology which has its birth after the invention of the microscope Microbiology is the study of all the aspects of microorganisms. While studying plants and animals, you started with the study of their structural features That aspect of study is *external morphology* or just *morphology* You have also to know the internal make-up of the plant. Similarly, you dissected an animal to learn about its internal organisation. The study of the internal organisation is *anatomy.*

Anatomical study has brought you in contact with the cellular organisation of the living body *Cytology* is a branch of biology which confines itself to the study of the cell structure and its functions. When you have studied the morphology and anatomy of an organism, say, a plant, you correlate them to its functional aspects The root serves to fix a plant to the ground and it also absorbs water and nutrients from the soil Likewise, the nervous system of an animal receives stimuli and conveys responses to the organs. So, you try to identify various organs with the functions they discharge. *Physiology* tells you the relationship between the form and function of an organism. The process of development in plants and animals is explained under *embryology*.

You know that plants are divided into groups like *Algae*, *Fungi*, *Bryophyta* and others Animals are grouped as Protozoa, Arthropoda, Chordata, and others *Taxonomy*, which names and classifies organisms, is yet another branch of biology. Besides the branches mentioned above, the biological studies also cover various other areas. An examination of the various strata of earth has brought to light the remains of plants and animals which lived millions of years ago. Such remains are known as fossils. Have you ever seen a fossil? *Palaeontology* is a branch of biology that tells you about the extinct forms of life A study of the fossils makes it clear that ancient forms of life underwent changes to evolve into new forms Based on this and other evidences available to them, the biologists have established the theory of organic evolution according to which life has evolved from simple forms to complex ones.

One of the remarkable properties of life is its continuity. All organisms pass on their characters from one generation to the next. The mechanism of this inheritance of characters is dealt with under *genetics* Both cytology and experimental work in genetics are responsible for our understanding of the mechanism of inheritance More intensive researches are in progress to know the chemical nature and properties of the substances involved in the transmission of the genetic information from the parents to the offspring

Nowadays, *ecology* has become a popular word and you come across it even in the daily newspapers Probably you do not understand what the term means. The study of living organisms *in relation to* the physical factors of the environment *and the relationship among themselves* is called ecology.

Biology has solved many problems for us. You will agree that one of its important branches is *agriculture* Agriculture is constantly improving on the basis of the findings in the different areas of biology You will come to know more of these in the chapters that follow. *Animal husbandry*, deals with the improvement of domesticated animals. Biological knowledge finds immense application in medicine, veterinary science, plant pathology, forestry, pisciculture, hygiene and industry.

TEST ITEMS

1. What are the most important contributions of the following scientists?
   (i) Aristotle (ii) Lamarck (iii) Vesalius (iv) Harvey (v) Leeuwenhoek (vi) Robert Hooke (vii) Charaka (vii) Sushruta.

2. Answer the following:
   (i) Morphology is the study of external forms of plants or animals.
   (ii) Anatomy is the study of ... .
   (iii) Cytology is the study of ... .
   (iv) Physiology is the study of ... .
   (v) Taxonomy is the study of ... .

3. Trace the link between morphology, anatomy and physiology.
4. How does palaeontology help us understand 'evolution'?
5. What does the term 'genetics' mean?
6. Why is ecology important?

CHAPTER 2

Diversities of Plants and Animals

1. Some elements like carbon, oxygen and hydrogen constitute both the living and non-living objects.
2. The living substance has physical and chemical characteristics. A living substance has certain other characteristics which are not present in the non-living substance.
3. Both plants and animals are living objects. They have certain common features, but they have differences also.
4. Diverse forms of plants and animals live on the earth.

In your earlier studies you became familiar with plants and animals, their way of life and behaviour. You know they are all living beings. What does this 'being alive' mean? What is an organism? What are the properties or characteristics exhibited by the living beings? How do they differ from or resemble the non-living? What form of diversity exists in the living world?

The most obvious difference between the living and the non-living is that the living things perform certain functions or life processes. What are these life processes? From your earlier study you could list them as metabolism, growth, reproduction, response to stimuli and organisation.

METABOLISM

In organisms a large number of chemical processes take place all the time. These chemical processes form the very basis of living activity, and without these the living matter will not stay alive. These chemical processes constitute what is generally called as *metabolism*.

Plants obtain water, minerals and CO_2 from the environment. These are the raw materials which the plant as an organism uses to synthesise organic products like fats, carbohydrates and proteins. Organic substances formed by the plant serve to keep the plant alive and build up its body.

To keep itself alive and growing, a bird, for instance, eats fruit All the materials necessary to keep the bird alive are supplied by the food it eats This aspect of metabolism is explained as nutrition Food primarily provides materials for building and maintenance of the body of an organism

Another aspect of metabolism is *respiration* (Fig 2 1). Any activity performed by an organism needs energy You walk, talk or run. All this is possible only when you have sufficient energy During respiration, the energy, available in the food consumed by you, is released. A plant also gets its energy from the food synthesised by it. This stored energy, released in respiration, is used to carry out other life activities

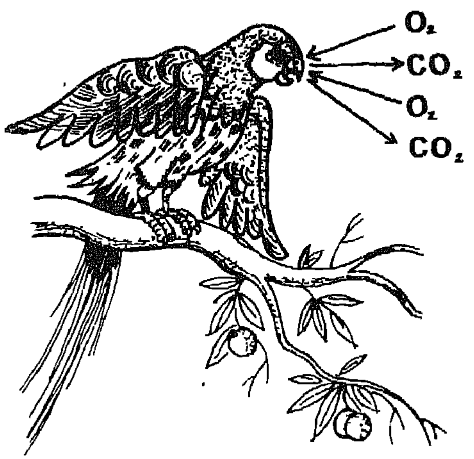


Fig 2 1 Respiration is a metabolic process. All land animals breath air containing oxygen

Yet another process associated with metabolism is *excretion* which eliminates metabolic wastes This is particularly obvious in animals. When the organism performs a number of interconnected chemical reactions, there is always the possibility of production of unwanted by-products, An accumulation of such by-products may endanger the normal functions of the organism Therefore, such by-products are collected and removed from the body by the excretory system Urine, sweat and exhaled air containing CO_2 are some of the excretory products.

GROWTH

In the act of metabolism, when the process of building up exceeds that of the breakdown, growth takes place Growth is defined as an irreversible increase in weight, size or volume of an organism (Fig 2.2). The metabolic activity produces living substance. This living substance is organised into new parts; sometimes it also replaces old ones. You are all familiar with the growth of a baby into an adult. A germinating seed develops and grows into a plant.

REPRODUCTION

'Like begets like' is a common saying. Mango trees produce seeds from which other mango trees grow up Dogs produce pups which in turn grow up. The resemblance of the offspring to their parents is a characteristic feature of life (Fig 2.3). Reproduction may be brought about by one or more methods. Organisms tend to perpetuate their kind through reproduction.

RESPONSIVENESS

A dog wags its tail on seeing its master. Roots of germinating seeds bend towards the force of gravity even though the seeds are placed in various positions How do you account for this ? The sight of the master is a stimulus which is perceived by a dog through its eyes. Wagging of the tail is the response. Gravity is the stimulus in the second example The growth of the roots in the direction of gravity is the response

By careful observation you can recognise responsiveness in various kinds of organisms. Responses are rather easily identified in animals than in plants In short you can say that response to stimuli is a feature of the living organisms A stimulus need not always come from outside. Hunger and thirst are internal stimuli to which animals respond by going in search of food or water. Have you seen some plants drooping their leaves at the end of the day ? Could you find out the reasons why the plants do like that ?

ORGANISATION

A living being is built of atoms just as any other object. An analysis shows that plants as well as animals are composed of a number of

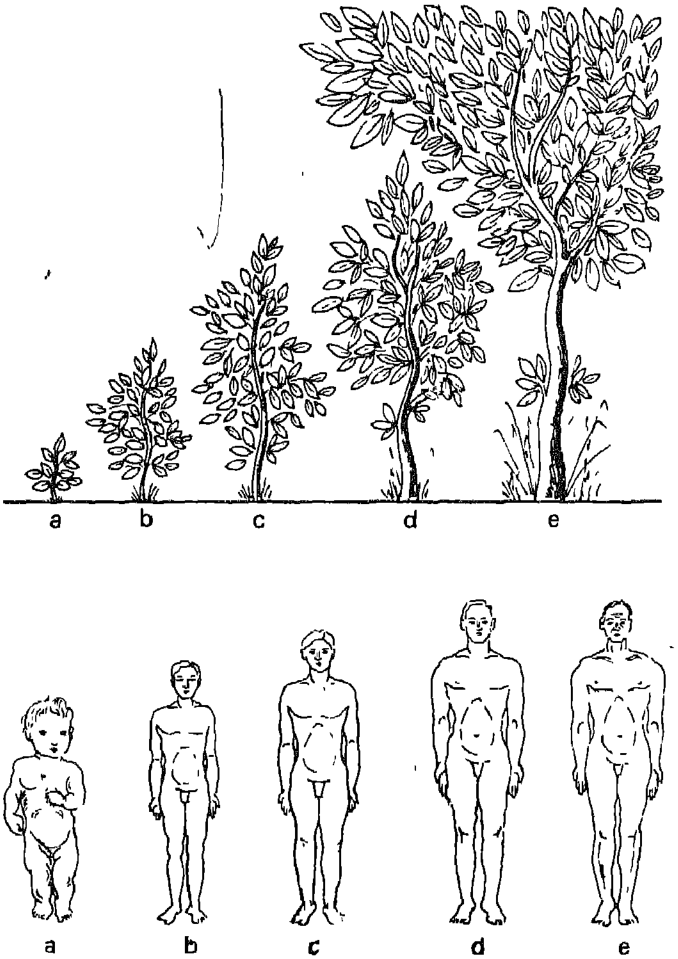


Fig 2 2. Growth is an irreversible increase in weight, size or volume of an organism. Growth in animals is restricted while that in plants is not elements. Atoms in the body of an organism are again united into simple and complex molecules Such molecules are again arranged to produce the subcellular units of cells like nucleus, mitochondria, plastids and other units. In unicellular organisms, the single cell carries out all the vital activities of life The next higher level of organisation of life you will find in the tissues which are built up of similar cells. The organs of the human body such as the liver, heart, kidney and those of a plant body such as the stem, leaf and root are all made up of various types of tissues. The circulatory system, reproductive system and photosynthetic system comprise of several interrelated organs The whole organism is a product of all these systems working in unison with each other. In all multicellular organisations, this type of multi-tiered organisation is evident. The secret of success in such an organisation lies in the efficient coordination of different parts, so that it works as an individual.

Fig. 2 3. Reproduction is the most important feature of living organisms

The above discussion will make you realise that life is a phenomenon that exhibits several characteristics which are unique to it Non-living objects do not exhibit these features.

LIFE IN PLANTS AND ANIMALS

So far you have studied the characters common to all forms of life. Yet, you must have noticed that plants differ from animals in some important respects What are these differences?

NUTRITION

A major point of difference between these two groups is traceable to their modes of nutrition Most of the plants are independent regarding their food requirement and preparation. Presence of chlorophyll helps green plants to synthesise simple carbohydrates by photosynthesis These plants are also able to produce a variety of organic compounds like fats and proteins from the basic substances prepared by photosynthesis It is because of these features that plants are called producers Do you know any plant which cannot produce its own food ?

Animals cannot produce their own food from simple raw materials They consume food produced by green plants. Usually the food is in the form of complex organic substances like proteins, carbohydrates and fats. For this reason, all animals are called consumers. Do you know any animal which can produce food like plants ?

LOCOMOTION

Most of the animals can move themselves from place to place. Plants generally remain fixed at a spot; they can obtain water and minerals by extending their roots into the soil;

other raw materials are taken from the atmosphere. Food of an animal, like a deer, will be exhausted if it stays in one place. And so it has to move.

ORGANISATIONAL DIFFERENCES

The digestive, circulatory and nervous systems are very well advanced in animals (Fig. 2 4). The complex organic food of an animal must be broken down or digested before it can be assimilated into its body, and so the need for the digestive system Digested food and inhaled oxygen are distributed through the circulatory system. Locomotion of any animal requires the presence of muscles and organs of locomotion. Proper locomotion is possible only when the organs of locomotion are coordinated by the nervous system. This coordination is also required for other organs. The sense organs help the animal to choose its food, avoid enemies and to respond to other stimuli. The excretory system is well formed in animals to eliminate harmful wastes resulting from metabolism

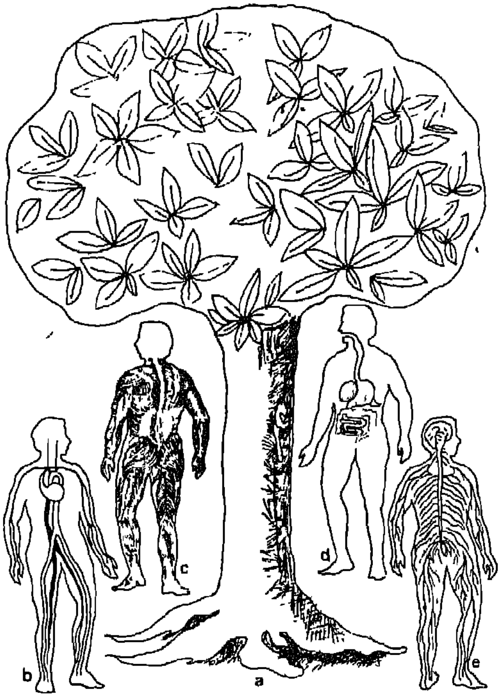


Fig 2 4 Organisation of a plant differs from that of an animal Some organ systems of man are absent in (a) plants, for example, (b) circulatory system, (c) muscular system, (d) digestive system and (e) nervous system.

Most of the plants have external parts to allow proper ventilation They also respond to stimuli but do not possess any nervous system. Plants respond to temperature, and even touch Transport of water and simple organic substances is effected through separate pathways called xylem and phloem. The organic food materials are built or broken down inside the cells of the plants. Very little is known about the excretory mechanism in plants.

GROWTH

Animals grow quickly over a period and reach a maximum size. Often there is no perceptible increase in size afterwards. This is advantageous to the animals' way of life. Otherwise, uncontrolled growth will make it difficult for an animal to move about.

A plant shows continuous growth. Locomotion is not its problem. More roots mean more water and mineral supply. Proliferation of branches and leaves increases the food production of plants.

CELL STRUCTURE

Plant cells are bound by rigid cellulose walls. In fact, you can say that these walls form the skeleton of the plant. But in the case of animal cells, there is no such cell wall, but only cell-membrane. Then again, inside the plant cell are structures called plastids. But the animal cell does not have them. Centro-

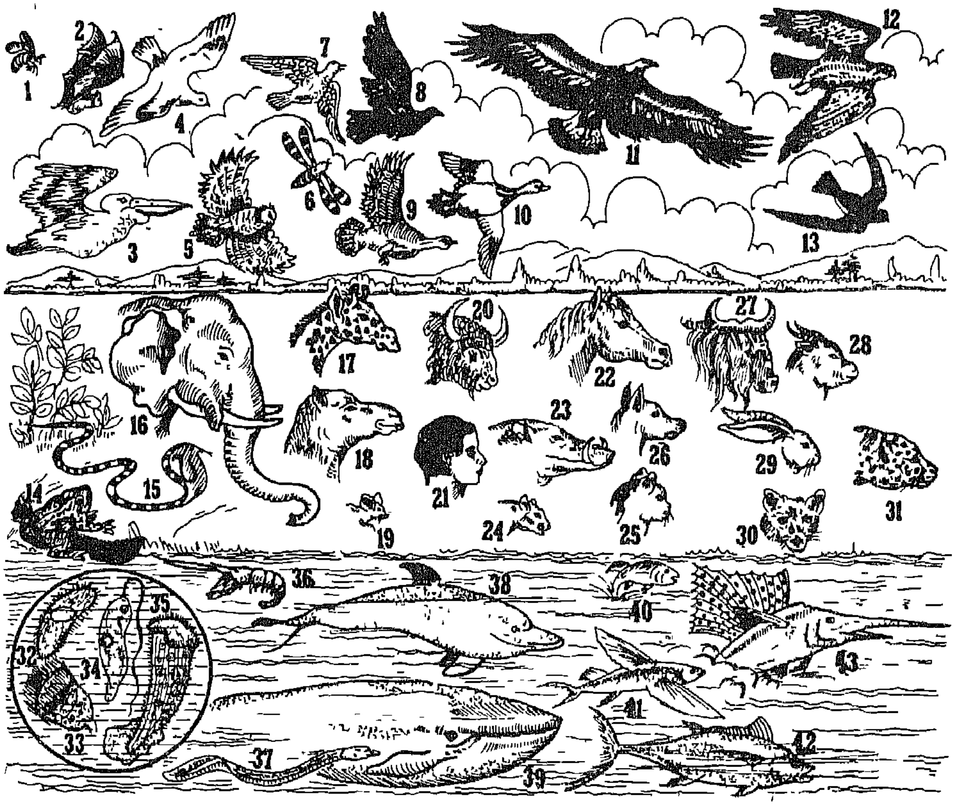


Fig. 2.5. A few of the different kinds of animals which we see on earth, 1 Bee, 2 Bat; 3 Pelican, 4. Herring Gull, 5. Great Horned owl, 6. Dragonfly, 7 Sterling, 8 Crow; 9. Wild Turkey, 10. Cavasback; 11 Golden Eagle; 12. Peregrien Falcon, 13 Indian Swift, 14 Frog, 15 Snake, 16. Elephant, 17 Giraffe; 18. Camel, 19 Mouse; 20 Bison; 21 Man, 22 Horse, 23 Hog, 24 Weasel, 25 Cat, 26. Dog; 27 Gnu, 28. Gazel; 29. Hare, 30 Fox, 31 Cheetah; 32-35 Various Protozoa, 36 Shrimp, 37. Eel, 38. Dolphin, 39. Whale; 40 Trout, 41. Flying Fish, 42 Tuna; 43 Sailfish.

some, which plays an active role during mitosis in an animal cell, is not found in plant cells. Vacuoles of various sizes occur in plant cells The animal cells seldom show vacuoles of noticeable size.

DIVERSITIES OF PLANTS AND ANIMALS

In the earlier sections of this chapter you have learnt about the characteristics of living things and also about the differences between the living and non-living, the plant and animal. Now you will learn about the great diversity of plants and animals that exist on this earth. This diversity includes the amazing world of microorganisms which includes tiny bacteria, other unicellular plants and protozoans on the one hand, and a great banyan tree, a majestic elephant and man himself on the other. As a matter of fact the earth is beaming with diverse forms of plants and animals (Fig. 2.5).

The science of life has also explored still smaller entity called viruses These microscopic particles, often with geometric shapes, are considered half way between living and non-living The viruses exhibit the power of prolific rates of reproduction, one of the important characteristics of life, when they live inside the living cells

If you look around you, you will find many types of plants and animals Observe them carefully Are they not different from each other in appearance, shape, size, habitat and in mode of life ? Yes, they are.

Even in a small area, say your village or city, forms of life greatly vary according to the physical nature of the habitats, i.e. meadow, pond, river, forest and others This variation is also seasonal Do you find the same birds, insects and weeds in your locality all the year round ?

Now if you consider the distribution of plants and animals at a global level, you will see the ecological conditions which include the physical nature of the habitats and climatic conditions (i.e temperature, sunlight, humidity, rainfall, etc.) play a major role in this diversity.

The characteristic living forms of polar regions (polar bear, walrus, seal, penguin, etc) are different from the living forms of sandy deserts (cacti, thorny shrubs, date palms, camels, desert snakes, lizards and others) or those of tropical ever green forests (palms, orchids, bamboos, different types of birds and mammals and others) The sea is the vast treasure of marine life which includes characteristic sea weeds, jelly fish, star fish, squids, octopus, sharks and whales

India is a vast country. Innumerably diverse forms of plants and animals are seen in its different regions with varied ecological conditions. In the northern border, the Himalayan region is adorned by its rich flora and fauna. This flora includes pines, rhododendrons, magnolias, birches, ferns and mosses among many others. The fauna includes the Kashmir stag, the Himalayan panda, flying squirrel and varieties of insects and birds The animal life of the Indian Peninsular region is characterised by spotted deer, nilgai, gaur, sambar, black buck, four horned antelope, sloth bear and others. The flora of this region includes thorny acacia, teak and bamboo among other plants. The grass jungles at the foothill of the eastern Himalaya are beautified by precious rhinoceros, the Sunderban area of the Gangetic plain by the famous Bengal Tiger and the gir forest of Gujarat by the rare Indian lion In this account we have given just a few examples of the varied forms of plants and animals that occur in India.

SOME EXAMPLES OF DIVERSE FORMS OF PLANTS AND ANIMALS AVAILABLE IN INDIA

Major Groups	*Examples*
PLANTS	
1 BACTERIA	*Escherichia coli*, *Diplococcus pneumoniae* and others
2 ALGAE	*Oscillatoria*, *Spirogyra*, *Volvox*, *Ulothrix* and others
3 FUNGI	*Yeast*, *Mucor*, Mushroom, etc
4. BRYOPHYTA	Liverworts (*Riccia*, *Marchantia* etc.) and different varieties of mosses.
5. PTERIDOPHYTA	Different varieties of ferns.
6. GYMNOSPERMS	Different types of pines.
7. ANGIOSPERMS	Lotus, water lily, water hyacinth, *Vasaka*, *sarpagandha*, neem, banyan, mango, etc.

ANIMALS

1. PROTOZOA	*Euglena*, *Amoeba*, *Paramoecium*, etc.
2. PORIFERA	Sponges
3. COELENTERATA	Hydra, sea anemone, jelly fish, etc
4. HELMINTHS	Fluke, tapeworm, roundworm, etc.
5. ANNELIDA	Earthworm, leech, marineworms, etc.
6. ARTHROPODA	Butterfly, moth, locust, honey bee, cockroach, spider, scorpion, prawn, crab, etc.
7. MOLLUSCA	Slug, snail, mussel, squid, etc
8. ECHINODERMATA	Starfish, brittle star, etc.
9. LOWER CHORDATES	Acorn worm, ascidian, amphioxus.
10 FISHES	*Rohu*, *Hilsa*, shark, sardine, etc.
11 AMPHIBIA	Toads and frogs
12 REPTILES	Snakes lizards, crocodiles, turtle and tortoise.
13. BIRDS	Peacock, *Mayana*, sparrow, crow, etc.
14. MAMMALS	Elephant, rhinoceros, lion, monkey, porcupine, etc.

There is, however, a unique unity among these diverse forms of plants and animals as a result of the similarities in the structural and cellular make-up of all these living beings There are also similarities in the various metabolic activities performed by the diversed forms of plants and animals You will learn more about this unity in diversity in Unit Three on life processes.

TEST ITEMS

1. What are the various aspects of metabolism ?
2. What do you know about responsiveness in plants and animals ?
3. Take two organisms, a plant and an animal; keep a close watch on both. Check whether the differences mentioned in the text are noticed in them.
4. How can you say that animals and plants have common features when you notice so many differences between them ?
5. What do you know about the diversities of plants and animals ?

CHAPTER 3

Origin of Life

1. For a long time man has been trying to solve the riddle of the origin of life.
2. All forms of life originated from pre-existing life, but the first living substance came from the non-living substances.
3. In spite of numerous interesting findings, the knowledge of the cause of life's origin is still incomplete.

THE PRE-BIOTIC EARTH

The pre-biotic conditions on the earth's crust were quite different from those in the period when biotic world began to develop. The origin of life was certainly a unique development of matter. This development actually involved a rather long sequence of chemical events (reactions) that resulted in the formation and further evolution of some sort of a 'living matter'. The whole phenomenon was a complex chain of events that has been described as the chemical evolution of life. Obviously, for chemical reactions to occur the availability of energy is essential. In the pre-biotic environment of the earth the possible energy sources that probably played a very important role in the occurrence of chemical reactions were : the sun, the radioactivity, the heat, the impact of meteorites, the electrical discharges through lightning, etc. The environment of the earth in the pre-biotic period had these sources in plenty. The sun was no doubt the prime energy source. The ultraviolet rays could be responsible for dissociating the atmospheric components into smaller units, radicals, ions and activated atoms, which in turn could recombine to form larger molecular organisations. Radioactivity, chiefly in terms of K^{40} was widespread in the crust of the planet earth and thus served as a source of gamma- and beta-rays. The volcanic eruptions, which were widespread, provided several gases that could have reached the oceans and given rise to organic molecules. The passage of meteorites through the earth's atmosphere could generate high temperature and pressure which could help significant chemical reactions to occur. Frequent electrical discharges in the forms of lightning could also provide energy for the reactions to occur.

The primitive earth had a higher average temperature than it has today. The atmosphere was full of hydrogen along with methane, ammonia and water vapour. So, it is often said that primeval atmosphere of the earth was reducing in nature. During this period the environment was devoid of oxygen. The present atmosphere of the earth, however, contains almost 20 per cent free oxygen. It is, therefore, particularly interesting to speculate the process of transition from such a reducing atmosphere to the present one rich in oxygen. There might have been two primary means by which free oxygen was subsequently made available: (1) The ultraviolet rays of the sun could dissociate water vapour present in the environment into hydrogen and oxygen. The former being lighter escaped into space while the heavier oxygen could be retained on the earth's surface by the gravitational pull of the later. Some of the oxygen molecules gave rise to ozone which formed a layer around the earth. The ozone layer around the earth's atmosphere protects the earth from many harmful rays from the sun. (2) Another source which increased the oxygen content of the earth's atmosphere was the photosynthetic activity of early plants. This, however, was a much later phenomenon. We know that as a by-product of the photosynthetic process, free oxygen is available in the atmosphere.

Thus, in the environment of the pre-biotic earth gases such as methane, ammonia, water vapour, hydrogen, some oxygen were present. These were suitable raw materials which, under the influence of energy, could interact to produce organic molecules which obviously formed the beginning in the evolution of living matter on the earth.

Now we turn to speculate on the course of possible events that might have culminated in the evolution of living matter, i.e. the origin of life on the earth. Two distinct phases characterised this evolution: first, from the inorganic to organic and secondly, from simple organic compounds to biological organisation.

The atmosphere around the earth contained water, methane, ammonia, free hydrogen etc. It is quite likely that, by utilising the energy of lightning, ultraviolet rays or cosmic radiation. these substances combined to form such organic molecules as amino acids, hydrocarbons, carbohydrates. These simple molecules led to the formation of useful organic biochemicals: peptides, polysaccharides, fats, etc. Further, molecular interactions might have led to the formation of proteins or protein-like molecules, Once a number of basic bio-chemicals were available, an aggregation of them can be conceived as forming the beginning of synthesis of living matter. One of the events of primary importance at this stage was probably the formation of membrane-like structure by the association of protein and lipid molecules. Consequently, the membrane-enclosed molecular aggregates containing organic biochemicals such as proteins, fats, carbohydrates, amino acids, nucleic acids, etc. were the precursors of living matter that gradually acquired properties of self-duplication and organisation into cell-like forms.

Some laboratory experiments have shown that it is possible to synthesise organic compounds in the laboratory from inorganic sources. For example, an American scientist, Stanley Miller (1953) synthesised amino acids from methane, ammonia, hydrogen and water under the influence of electric spark as an energy source. These simulation experiments provide reasons to believe that organic molecules were formed on the surface of the primitive earth, through the pathways very similar to those followed in the artificial laboratory experiments.

LABORATORY EXPERIMENTS AND BIOLOGICAL MOLECULES

Miller's experiment was a unique simulation

Stanley Miller

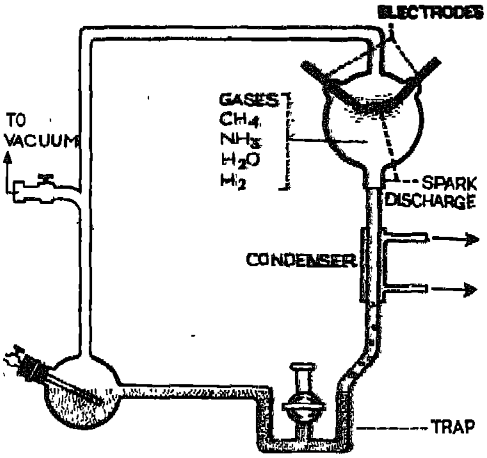


Fig. 3.1 Stanley Miller's Experiment

of the primitive, pre-biotic atmosphere of the earth. The apparatus was designed to circulate a vapour of methane, ammonia, hydrogen and water and to allow a passage of an electric spark which served as the source of 'lightning'. The electrodes which generated the spark were placed inside a flask (Fig. 3.1). The sparking continued for a week. The mixture of water vapour and gases condensed as they passed through the condenser.

When the water was examined, it was found to contain a large number of organic compounds, including four amino acids, namely, glycine, alanine, aspartic acid and glutamic acid.

A number of similar experiments[7] have been done subsequently by others. Cyril Ponnamperuma and Melvin Calvin (1963) studied the action of ionising radiation on the inorganic compounds and obtained results similar to Miller's. Others tried with ultraviolet light, heat and several other sources of energy and obtained amino acids, purines, pyrimidines, carbohydrates and hydrocarbons as end products. All these results substantiate the assumption that organic molecules were synthesised out of inorganic materials and the energy source necessary for the reactions were electrical discharges, ionising radiation, ultraviolet rays and the like.

We know that amino acids are the smaller units of the protein molecules. Perhaps they were synthesised from aldehydes and nitrites. Formaldehyde (HCHO) and hydrogen cyanide (HCN) were the representatives of aldehydes and nitrites respectively on the primitive earth. An aldehyde and a nitrite might be combined in the presence of ammonia to yield amino acid as follows:

$$RCHO + NH_3 + HCN \rightarrow \underset{\text{(intermediate product)}}{RCH(NH_2)\,CN + H_2O}$$

and then,

$$RCH\,(NH_2)CN + 2H_2O \rightarrow \underset{\text{an amino acid}}{RCH(NH_2)\,COOH} + NH_3$$

It is probable that the aldehydes and the nitrites were formed in the gas phase of the spark in Miller's experiment

There are alternate suggestions as to how the amino acids were formed. But what is important here is that the simulation experiments suggest how readily they were formed in the primitive earth

Not much is known about the possible machinery by which the components of the nucleic acids were initially synthesised. Some scientists suggest that hydrogen cyanide was the precursor of adenine, one of the nitrogenous bases

It has been experimentally shown that the deadly poison hydrogen cyanide is formed out of methane, ammonia and water vapour by electrical discharges A primordial synthesis of bases other than the adenine, however, could not be simulated in the laboratory.

Amino acids or nucleotides are small units of complex, polymers, the proteins and the nucleic acids. The process of polymerisation or intermolecular union of the units was a gradual phenomenon. We know from our present knowledge that one amino acid is linked with the other by what is known as a peptide bond In the process of formation of this bond, one molecule of water is eliminated. Similarly, a molecule of water is removed when one nucleotide is linked with the other to form the long nucleic acid chain Thus, the removal of water molecule is a necessary step towards the synthesis of a polymer From a number of simulation experiments we have come to understand that polymerisation of amino acids took place in the past in exactly the same way of dehydration, i e. by the removal of a water molecule But though we have stated above how the nucleotides polymerise, we have no evidence to conclude that they did so in a similar way in the primitive earth. How these polymers of nucleic acids acquired the power of replication is also unknown.

The story from this molecular organisation to proto cells is still largely unknown

TEST ITEMS

1. What are the different elements which took part in the formation of the first living substances?
2 Describe the experiment of Stanley Miller.
3 The question of origin of life is still unsolved Why?

UNIT—2

ORGANISATION OF LIFE

CHAPTER 4

Levels of Organisation

1. There exists something common in all living things.
2. The mystery of life lies in its organisation.
3. The organisation exists at several levels.

A PLANT is distinct from the soil in which it grows and a fish from the water in which it lives. Both plant and fish possess a certain degree of *organisation* which enables them to perform various activities of life. The organisation of the living matter is observed at several levels. The largest level of organisation of the living matter is a complete living *individual*—a plant or an animal. This large unit of life is a very complex state of organisation. Each individual is made up of a large number of *organs*. Each organ is composed of several tissues which are aggregates of similar *cells*. A cell is the smallest structural unit of any living organism. If a cell is split further, it will be seen to be made up of organic and inorganic *molecules*. This is the smallest level of organisation of any living substance.

Let us now consider the various levels of organisation in some details.

HIGHER LEVELS OF ORGANISATION

The biosphere is the largest unit of organisation which includes the living organisms of various geographical regions of earth. Various geographical regions are often markedly different according to the nature of vegetation and animal life living in these regions. The natural ecological groupings of plants and animals of various geographical regions are known as *biomes*. Thus, the term *biosphere* includes all the biomes of the world, i.e. the aquatic, terrestrial or aerial. In other words, biosphere includes the total world of life (Fig. 4.1).

The *biome* or *ecosystem* is a smaller unit of organisation in comparison to biosphere. The living organisms which are found in a definite geographical region together with the physical environment of that region constitute a biome or ecosystem. In each ecosystem several com-

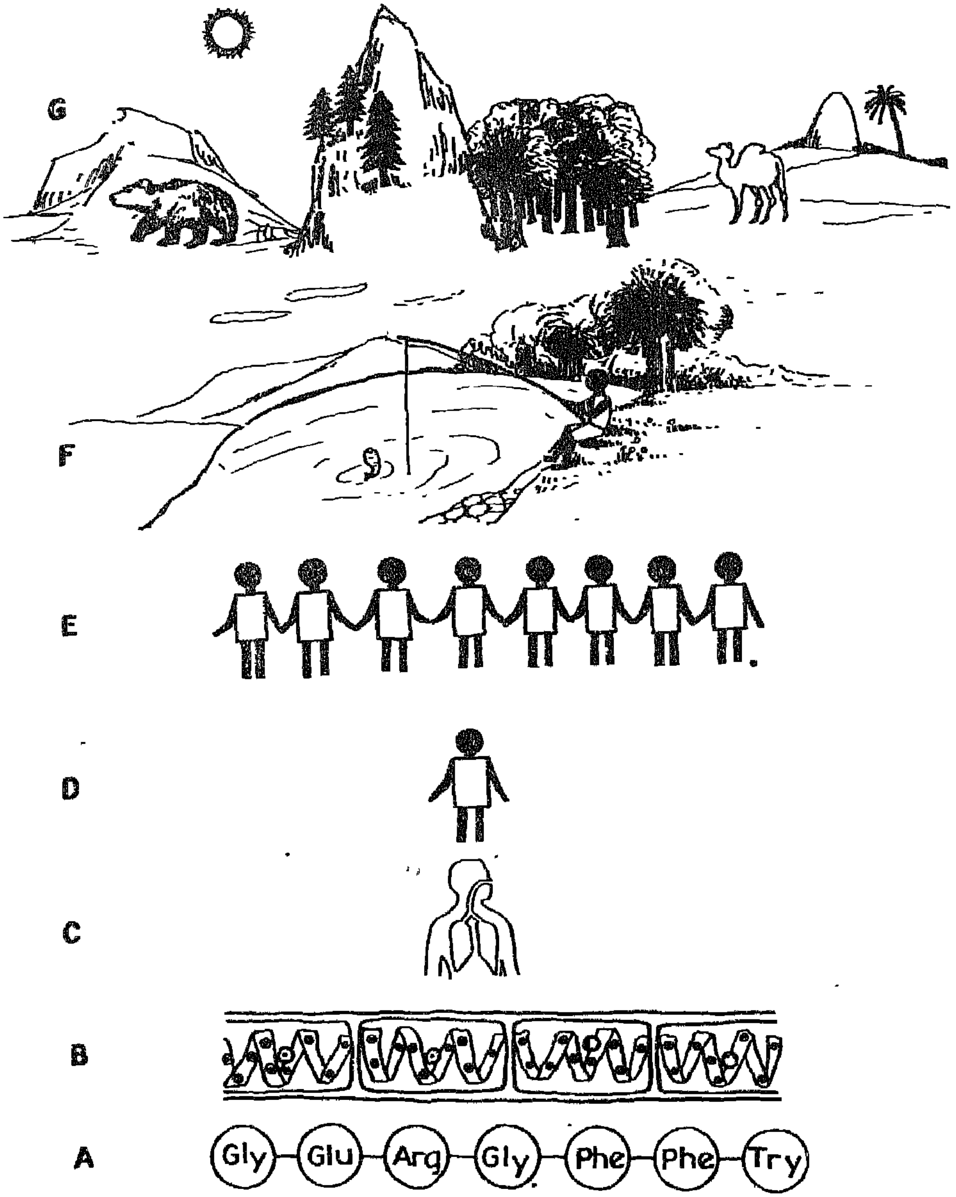


Fig. 4.1. Different levels of organisation; A. Molecular level; B. Cellular level; C. Organ level; D. Individual level; E. Population level; F. Ecosystem and G. Biosphere.

munities or organisms are found which are dependent on the non-living environment of the ecosystem.

A *community* includes several populations of plants and animals of a particular locality which are associated with each other for their existence. *Population* is again a smaller unit of organisation in comparison to a community. In each population several individuals of a species of plants or animals are found. Similar kinds of individuals cooperating among themselves for sustaining their life (at least for sexual reproduction) form a *species*. A species may have several individuals. The sequence of higher level of organisation would be:
Biosphere←Biome←Community←Population←Individual.

ORGANISMAL INDIVIDUAL LEVELS OF ORGANISATION

You have examined a scale of onion and seen that it is made up of numerous *cells*. Similarly, the human body, is made up of many billions of cells. All of them are not of the same type. They are organised into different tissues, for example, epithelial tissue, connective tissue and nervous tissue, for carrying out certain specific functions. Different kinds of tissues are again organised to function as *organs*. In our body, kidneys, liver, stomach, etc., are organs, each composed of several kinds of tissues. Thus the individual holds the highest position in this level. This is organismal organisation. The sequence of organismal level of organisation would be:
Individual←Organs and Organ systems←Tissues←Cells

CELLULAR LEVEL OF ORGANISATION

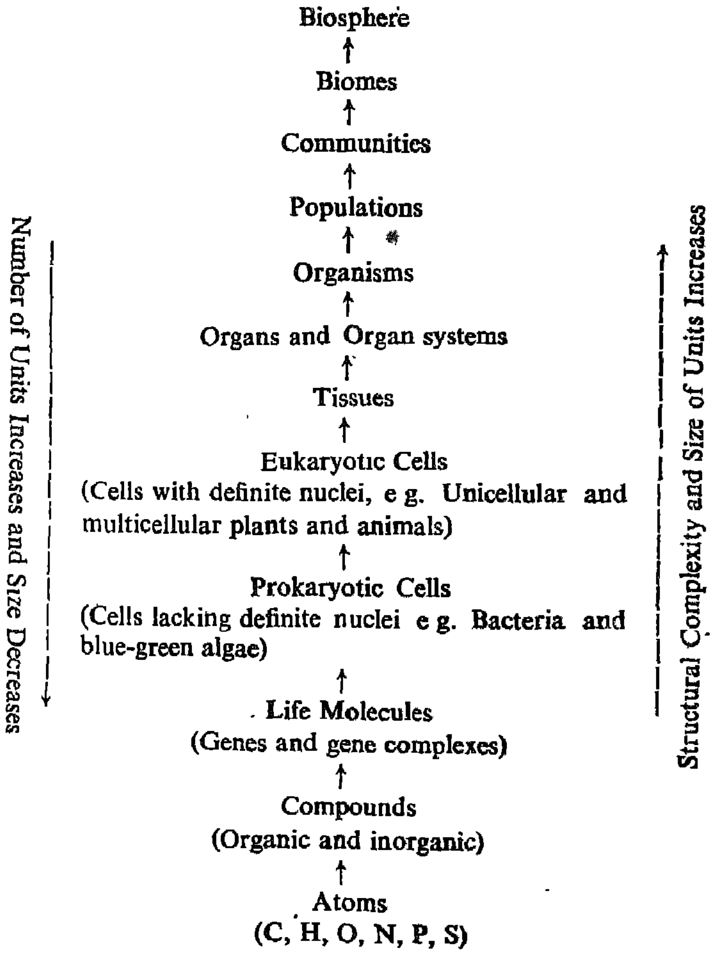
A *cell* is a mass of protoplasm enclosed in a membrane and contains a nucleus. This is another level of organisation exhibited by all living forms and is referred to as *cellular organisation*. The cells are the structural and functional units of the living body. In fact, bodies of organisms are entirely made up of cells and their products

On the basis of basic architecture, two types of cells are recognized: the *eukaryotes* and the *prokaryotes*. The cells with definite nuclei are named eukaryote cells. The cells of all animals and plants excepting bacteria and certain algae belong to this group The cells which lack definite nucleus such as bacteria and certain blue green algae are included in the group prokaryotes. Instead of having a definite nucleus, the prokaryotes have a nuclear zone where the chromosome is located.

MOLECULAR LEVEL OF ORGANISATION

Most of the chemical elements found in the living beings are organised in the form of varieties of special kinds of molecules They are proteins, carbohydrates, fats, nucleic acids and vitamins. In addition to these, there are some inorganic salts and water. The two most unique types of molecules which form the very basis of life are the *proteins* and the *nucleic acids*.

In all the living forms, besides the nucleoprotein molecules other materials mentioned above aggregate in turn and get precisely organised. This highly complicated form of substance is known as *protoplasm* Protoplasm is bestowed with *all* the basic properties of life—metabolism. irritability and reproduction. The composition and activity of protoplasm are never constant. The chemical and physical states of protoplasm change from moment to moment, and vary in different parts of the body and in different organisms. This arrangement of molecules in the protoplasm is one level of organisation in the living, that is, *molecular organisation*.


Biosphere
Biomes
Communities
Populations
Organisms
Organs and Organ systems
Tissues
Eukaryotic Cells
(Cells with definite nuclei, e g. Unicellular and multicellular plants and animals)
Prokaryotic Cells
(Cells lacking definite nuclei e g. Bacteria and blue-green algae)
Life Molecules
(Genes and gene complexes)
Compounds
(Organic and inorganic)
Atoms
(C, H, O, N, P, S)
Number of Units Increases and Size Decreases
Structural Complexity and Size of Units Increases

Hierarchy of Levels of Organisation.

TEST ITEMS

1. What is the common feature in all living organisms ?
2. "Simply putting together of all elements in a mixture of right proportions and supplying them with energy from an outside source will not enable it to perform the life activities". Can you justify the statement ?
3. What are the different levels of organisation in the living world ?

CHAPTER 5

Individual, Population and Community

1. Several kinds of organisms live together in a particular area.
2. Each kind of organisms is represented by several individual members This is called the population of that kind of organisms.
3. A species may include several population units living in different geographical localities.
4. The size of a particular population is determined by measuring the density of the population. No population can exist in isolation.
5. A community is a self-contained biological unit where population of different species associate.

AN individual organism, be it a plant or an animal, whether of one cell or of billions of cells, is a biological unit. It performs all the essential living processes to maintain itself. But can it live an absolutely isolated life ? No. Let us take the example of man. Are we really alone ? We are associated with other individuals of our own kind in the locality. This is also true of all plants and animals. They live together and propagate their own kinds. The individual dies but the group formed by the association of the individual members survives. This association of individual members of the same *species* living together in a particular locality is called a *population.* The earthworms in your school lawn, the lotus plants in a pond, the lions of the Gir forest are examples of such populations

POPULATION AND SPECIES

A *species* is a group of individuals capable of interbreeding to produce fertile offspring. A population is a geographically localised group of individuals of the same species; individual members are capable of interbreeding within the group. This is called a *biological population.* A species may include several population units living in different geographical localities. Can you name one species which lives in different geographical localities ?

CHARACTERISTICS OF A POPULATION

The organisation of population is at a level higher than that of the organism. The characteristics of a population denote the characteristics of the group rather than that of the individuals.

A population, as it has been defined, is a group of organisms of the same species occupying a certain space. The size of a population may vary depending upon the available space, food and other conditions. If the space is limited and the number of individuals per unit of space increases, then you can say the population is denser.

POPULATION DENSITY

The population density is the main structural characteristic of a population. It is expressed as the number of individuals or biomass /per unit area or volume. 'Area' is used for land organisms and 'volume' for the aquatic ones. For example, 40 lions per 100 square kilometres, 500 sal trees per hectare, 5 million diatoms per cubic metre of water; 10 paramoecia per cubic milimetre of water.

Different techniques are used to find out the population density, of different kinds of populations. For large animals like the wild buffalo, rhinoceros or elephant, population density can be found out by *total counts* For various kinds of organisms such as plants, zooplanktons, earthworms and insects, the population density is measured by *sampling*. What is sampling ?

EXPERIMENT

You may study the density of a particular plant population in your garden.

Select five different areas, each a square metre in your school garden. Count the number of any one species of plant in each of the sample unit area.

Record your observations. What is the density of the particular plant species in the garden ? To do this, add the number of plants in each unit and divide by five. This will give you the density per unit area.

Repeat the above experiment in winter, summer and rainy season. You will find that the density varies with the seasons.

There are other methods of finding out the density of a mobile population. Particularly animal population density is measured by marking, counting pellets and foot prints. Does the density of the population remain the same all through the year ?

The density of a population not only varies with seasons but also tends to decrease or increase in a longer span of time. Some animals and plants of the past have become extinct.

Factors Affecting Population Density. The population density of any organism in a given time and a given space is determined by four factors: birth rate, death rate, immigration rate and emigration rate.

Birth rate. It is the rate at which new members are added to a particular population by reproduction.

Death rate. The rate at which the individuals die out is called the death rate.

Immigration rate. It is the rate at which individuals move into a population.

Emigration rate. It is the rate at which individuals move out of a population.

Out of the above four characteristics of a population, immigration rate and emigration rate affect only the mobile organisms and not immobile organisms like trees. Trees do not move about. Mobility is a characteristic of most of the animals In addition to immigration and emigration, there may be migration, that is, periodic departure and return. Migration does not affect the population size, but immigration and emigration do.

You know that in every family, the birth of a child increases the family size and a death reduces the number of the family members. Coming of a guest would be similar to immigration and departure of a person for a job elsewhere would be like emigration. A city like Delhi has grown largely by immigration of people from different parts of the country Initial growth of the United States of America was largely due to the European emigrants.

Effects of the Environment on Population: The above factors which determine the population density are themselves variable This variation is caused by the environment around the population. Everything outside the population constitutes its environment. The environment of any population consists of two components

1 The living or the biotic environment, and
2. The physical or abiotic environment

All plants and animals in the surroundings of an organism constitute the biotic environment Everything that is not alive in the surroundings like soil, water and solar radiation, constitutes the abiotic environment Both the biotic and abiotic environment may cause variation in the size of a population by affecting the following: (1) nutrient supply, (2) available space, (3) interaction with other organisms, and (4) weather

Nutrient Supply: All organisms depend upon their environment for the supply of nutrients. The available nutrients, both organic and inorganic, may either be abundant or in short supply. If they are in abundance, the population will flourish. On the contrary, if the essential nutrients are missing, the population size will decrease. The presence of a particular nutrient in less than the required amount would nearly proportionately reduce the population size.

Available Space: The habitable space is one of the primary needs of organisms. Individuals, pairs or family groups of animals commonly restrict their activities (for search of food and mate) to a definite area called the *home range* If this area is actively defended it is called a *territory* For example, the Gir forest is the home range of both lions and leopards. Both lions and leopards enjoy some part of this home range as their territory. The home ranges of different members of a population overlap with one another but not their territories (Fig. 5 1)

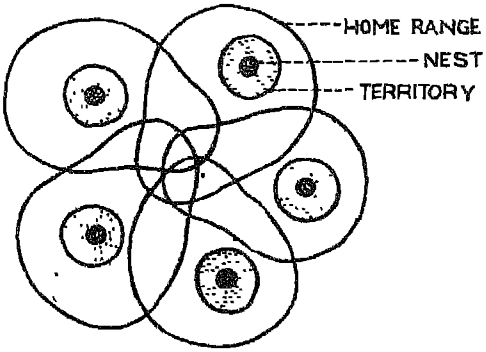


Fig 5.1. Home range, territory and nest

The nutrient supply may be in abundance but the living space per individual member of a population may become too small for the continuance of its normal activities such as reproduction and care of the young In such a situation a struggle to maintain space between the members will become evident.

Interaction with other Organisms: The population in nature is simultaneously exposed to various environmental factors The density changes involve the interactions of various biotic and abiotic factors. Actually these factors are the struggles between the various individuals of the same and different species for food and shelter These interactions are:

1. Between the members of the same species (intra-specific interaction)

2. Between the members of different species (inter-specific interactions), and
3. With the abiotic environment.

These interactions tend to maintain a constant size of the natural population.

Weather: The abiotic factors like sunlight (intensity, duration), temperature, water (rainfall, humidity) and pressure constitute weather. They act as limiting or regulatory factors of population size The unequal distribution of rainfall during the year affects the density of population of many plants and animals. The density of population of some plants and animals increases sharply just after the rain and decreases with the approach of winter. High mortality and emigration rate are found among cattle population in areas affected by drought.

Malarial parasites are rare in temperate regions but are prevalent in tropical humid regions. Do you know the reasons ?

An increase in the relative humidity accelerates the larval development of flour beetle. The young silver fish dies if the relative humidity falls. Normal activities of most of the animals including man, are possible only within an optimum range of temperature,

The population density of green plants decreases from the sea surface to a depth of 200 metres in proportion to the decrease in the intensity of light. Below 200 metres, no green plant is found, The variations in the duration and intensity of light from place to place determine the distribution of green plants.

COMMUNITY

No population can exist in isolation. In any environment, a population is associated with several different populations of plants and animals. This association of several populations of different species in a particular locality is known as a *community*. It is often referred to as a *biota* or *biotic community*.

The association of different kinds of plants and animals in a pond constitutes the pond community. The different kinds of organisms living together in a meadow constitute the meadow community. Likewise, those living in a forest constitute the forest community. Even a large number of organisms living in a fallen log constitute a biotic community.

A community is a self-contained biological unit at a level higher than that of a population. A community has the following characteristics: (1) trophic organisation, (2) stratification; (3) dominance, (4) variety; (5) interaction and (6) succession.

CHARACTERISTICS OF A COMMMUNITY

Trophic Organisation: A community is characterised by a definite *trophic organisation*, that is, the trophic levels. All the species of a population living in a community can be divided into three trophic levels: *producers, consumers* and *decomposers*.

All the green plants in a community constitute its *producers* They synthesise food for the entire community.

The food produced by the green plants is consumed directly or indirectly by all kinds of animals and a few non-green plants. They are the *consumers* of the community. Consumers may be *herbivores* or *carnivores*. The animals that feed on plants are called herbivores and those which feed on other animals are called carnivores. Can you name at least five animals of each group ?

The dead bodies and excreta of the producers and consumers are broken down (decomposed) by some organisms such as bacteria and fungi, into simple substances. These organisms are called *decomposers*. The products of decomposition which include carbon dioxide, nitrates and phosphates among others are used again by green plants to produce food.

Stratification. In large communities, terrestrial or aquatic, the population of each species occupies a particular strata. This phenomenon is called *stratification*. In a forest community, the tree tops, the lower branches, the leaf litter and the soil bottom are occupied by different species. A pond community likewise has surface dwellers, bottom dwellers and dwellers of the intermediate depths.

Dominance. In any community, one or a few species dominate either in numbers or in physical characteristics or in both over the other species. In a grass-land community, grass, and in a pine forest, pine trees, constitute the dominant species.

Variety of Species. Species vary from community to community. A great variety of species are found in the tropical rain forest community, whereas a few species constitute the polar community.

Interactions between Organisms. The interaction between one organism and others arises on account of the organism's primary necessities of life-food, reproduction and protection. The interactions between organisms in a community result in different kinds of relationship as shown in Table 5.1.

TABLE 5.1

DIFFERENT KINDS OF RELATIONSHIPS IN A COMMUNITY

Relationship	*Interacting Organisms*
Predation	Predator-Prey
Parasitism	Parasite-Host
Scavenging	Scavenger-Dead animal
Commensalism	Benefited-Unaffected
Mutualism	Benefited-Benefited
Competition	Competitor-Competitor

Predation. Predation is the direct food relationship between two organisms when one eats the other. The eater is called the *Predator* and the eaten *prey*. The lion eats deer, the snake eats rats. Thus in these instances, the predator-prey relationship exists between the lion and deer, the snake and rat. In the above example the snake is a predator for the rat.

A predator population may either regulate or limit the prey population within a community.

The relationship between the prey and the predator develops and becomes established in time in a stable community, where predation acts as a regulating factor to check the prey population. Otherwise the prey population will exhaust the resources on which it thrives.

Parasitism. Parasitism is the food relationship between two organisms when one organism lives *on* or *in* another and obtains food from it. The former is called the *parasite* and the latter, the *host*. The *ectoparasites* live *on* the host whereas the *endoparasites* live *in* the host. When the parasite itself is parasitised, the relationship becomes *hyperparasitism*.

Like a predator, a parasite may be a regulating or limiting factor of a species population in a community. Unlike the predators which have some freedom of choice in their prey, most parasites are host-specific When a population of parasites kills the host, it could become disastrous to the parasites as well. Many parasites have complex life cycles involving an intermediate or an alternate host For example, the intermediate host in the case of malarial parasites is the mosquito.

Man has utilised his knowledge of parasitism to biologically control the pests.

Scavenging. Scavenging is the food relationship between a dead animal and its eater The eater or consumer is called scavenger (Fig. 5.2) The hyaenas, the vultures and the jackals are well-known scavengers. They provide the best sanitary services to forests, towns and villages

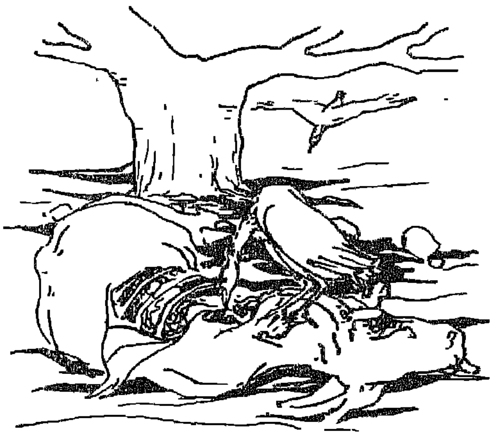


Fig 5.2 Scavenging. A vulture is eating the remains of a dead animal

by cleaning the dead animal debris. The vultures are universal scavengers, whereas the hyaenas chiefly serve the forests. The jackals are the scavengers of small towns and villages.

Commensalism It is the relationship between two organisms when one is benefited and the other remains unaffected (Fig. 5.3). It represents the first step towards the development of beneficial relations

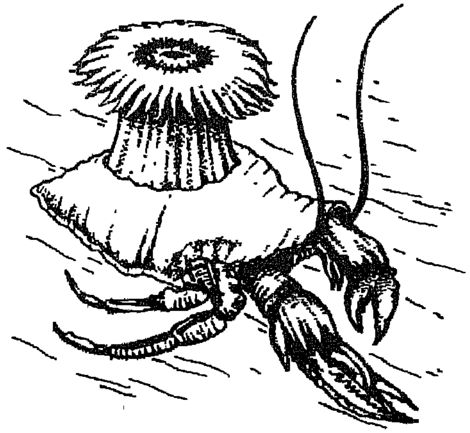


Fig 5.3 Commensalism · A sea-anemone attached on the shell of a hermit crab.

For example, epiphytes use trees only for attachment. They manufacture their own food and do not obtain nourishment from the host tree. *Escherichia coli* found in the human colon consume undigested food and complete their life cycles in the host which itself remains unaffected. Sucker fish is found attached to the underside of sharks and feeds on the fragments of food resulting from the sharks meal.

Mutualism. It is a relationship between two organisms where both obtain some benefits (Fig. 5.4). The term *symbiosis* is sometimes used in the same sense as mutualism, sometimes the term is used to cover commensalism and parasitism as well. Since symbiosis literally means 'living together', the word is used in a broad sense

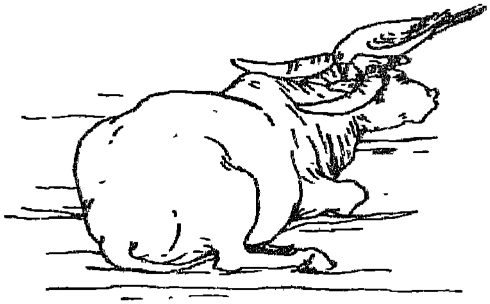


Fig. 5.4. Mutualism : The partnership between a buffalo and a crow: the crow feeds on the skin parasites of the buffalo.

Many examples of mutualism can be given. In the partnership between the tick bird and rhinoceros, the tick bird feeds on the skin parasites of the rhinoceros which gets relief. If it becomes necessary, each can live without the other. Similar association exists between coelenterates and crabs.

The mutualism found between legumes and the nitrogen-fixing bacteria is more intimate (Fig. 5.5). The bacterial nodules on the roots of leguminous plants fix nitrogen for the use of plants and in turn derive nutrition from the plants.

Commensalism and mutualism illustrate how cooperation in nature is important for survival.

Competition. Competition is the interaction between two organisms that strive for the same thing; both competitors may belong to the same species (*intra-specific competition*) or to different species (*inter-specific competition*).

Competition generally results in a balance between the resources and the number. For instance, the thickly populated plants of the tropical evergreen forest compete for light Likewise, the competition for shelter among the house sparrows is very common in the urban houses

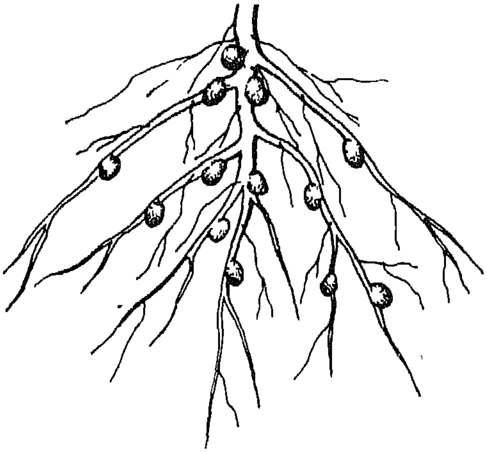


Fig 5.5. An example of intimate mutualism between the roots of a leguminous plant and nitrogen fixing bacteria nodules

The competition among plants mainly occurs for light and nutrients, and among animals for food and shelter In addition, the intra-specific competition occurs also for mating partners.

The intra-specific competition regulates the species population, and it may limit the population density of both the competitors, or eliminate either of the two completely, or force one to move into a different area

ECOLOGICAL SUCCESSION

Ecological succession is the development of ecosystem and can be defined in terms of the following three parameters

1. It is an orderly process of community development
2. It results from modification of the physical environment by the community.
3. It culminates in a stabilised ecosystem

Thus ecological succession is a community-controlled modification wherein a community of plant and animal population is succeeded by a new community of plant and animal population. The succession is a directional change and continues until a stable or climax community is established

The ecological succession starts from a virgin land or rock (sand dunes, lava sediments) Water and nutrients are extremely deficient in such environments The rocks are exposed to sun, storms and extremes of temperature Thus, the rocks are invaded first by the most hardy organisms like the lichens These lichens decompose the rock by secreting acids By mixing rock particles with their own remains they make the conditions suitable for the growth of foliose-lichen stage. By the activity of foliose-lichens a thin layer of soil on which mosses can grow is collected In the new situation mosses will dominate and may replace the lichens totally. By their death and decay a mat may be formed on the rock surface which can retain more water to give a favourable condition to the growth of annual grasses These annuals are later replaced by perennial grasses, shrubs and finally the trees along with their characteristic animal population (Fig. 5 6).

The natural communities like forests and grasslands represent the climax communities that maintain a steady state When man clears the forest or destroys the grassland by grazing his livestock, he reverses the process which, left to itself, will recover through the same successional stages.

A destroyed grassland may take 50 to 100 years or more to reach the climax vegetation again But the time factor involved in the development from bare sand dunes or lava sediments to a climax forest may be at least 1,000 years.

The crop fields and the forests represent the successional and climax forms respectively, and a balanced maintenance of the two is unavoidable for the human welfare

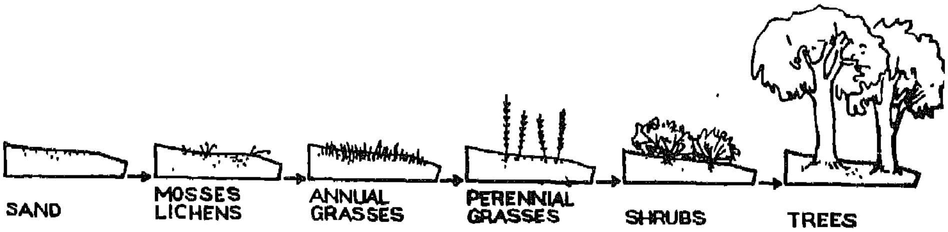


Fig 5 6. Biotic succession continues until a stable community is established.

TEST ITEMS

1 Supply the scientific terms for the following statements·
   (i) Geographically localised association of the same kind of individuals.
   (ii) A number of individuals of the same species living per unit area of space.
   (iii) The rate at which individuals move out of a population.
   (iv) The rate at which death occurs in a population.
   (v) The area which an organism defends against others of the species for the purpose of breeding.

2 Complete the following sentences with suitable words:

(i) The environment consists of two components—— ———or————and physical or————————

(ii) The abiotic factors together constitute the—————— ——

(iii) The—— ———of an animal is a defined area which the animal covers in search of food and mates.

(iv) Everything that is not alive in the surrounding constitutes the————environment.

(v) The rate at which birth occurs in a population is called——————

3. Answer the following

(i) What is a population? What is its characteristic? How does the environment affect a population?

(ii) What are abiotic factors? How do they affect a population?

4. Give a tick mark against the correct answer:

A community is an association of

(i) the members of the same kind.

(ii) similar kind of organisms.

(iii) several populations of the same species.

(iv) several populations of different species

5. Which one of the following statements is the most applicable to a parasite? It is an organism which

(i) lives on another and obtains food from it

(ii) lives on or in another and obtains food from it.

(iii) depends upon others for its food.

CHAPTER 6

Organs, Organ Systems and Organisms

1. In a unicellular organism, the single cell is organised to carry out all the vital activities
2. Some plants and animals have bodies made up only of one type of cell.
3. Hydra is an animal in which there is organisation only at the tissue level.
4. Several tissues take part in the formation of an organ which performs one or two specific functions.
5. Several organs unite to form an organ system which carries out one vital activity. The life activities of an individual are the result of the working of different organ systems

ALL living things exist as individual organisms. Some are unicellular, some have only a few cells, and others have billions of cells. In higher multicellular organisms, as you know, cells form distinct tissues The tissues, in turn, are combined to form organs Several organs take part to form an organ system for a particular function Most of the plants and animals that we see around us are formed of such organ systems.

ORGANISATION AT CELLULAR LEVEL

There are numerous small organisms which are unicellular (Fig. 6 1). In these the living matter is organised at cellular level only. The body is a single mass of protoplasm Structurally, these organisms appear very simple, but functionally they may be compared with the higher organisms They all share with the higher organisms the vital life processes.

Let us discuss two examples of this organisational level. In amoeba, which is structurally a single cell, we can see several specialised organelles which function almost as efficiently as organs of higher animals. In the process of alimentation, for example. ingestion is performed by pseudopodia; digestion is carried out by the food vacuole; absorption is done by vacuolar membrane, and finally, the undigested portions are egested.

Paramoecium moves with the help of cilia. It takes in food through a mouth-like cell struc-

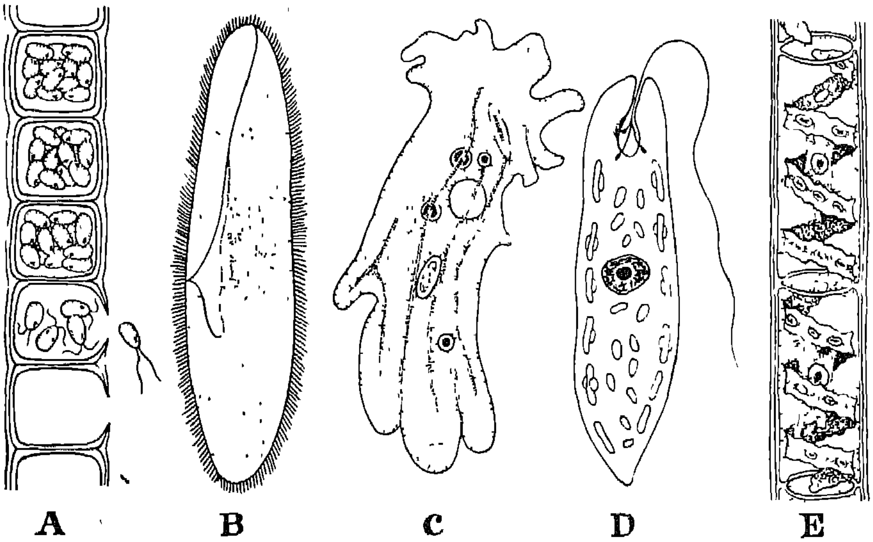


Fig 6 1. Some unicellular organisms : A. Ulothrix, B Paramoecium; C. Amoeba; D. Euglena; E Spirogyra

ture called *cytopharynx*, and egests the undigested material through another cell structure called *cytopyge*.

ORGANISATION AT TISSUE LEVEL

There are organisms made of almost the same kind of cells, or we can say, organisms made of only one kind of tissue. Certain algae like *Spirogyra*, *Ulothrix* (Fig. 6.1) and *Volvox* are examples of such organisation. In *Hydra*, we see a further degree of specialisation (Fig. 6.2) The body wall is made of two layers of cells

In higher plants and animals there are several kinds of tissues. Let us now examine how these tissues are organised into the next higher level of organisation.

ORGANISATION AT ORGAN LEVEL

You all know that a leaf is a plant organ and that the main functions of the leaf are synthesis of food, transpiration and respiration.

What are the different kinds of tissues found in a leaf ? There is *epidermis* at the upper and lower surfaces, protecting the internal tissues of the leaf. There are *stomata* on the lower surface to facilitate gas exchange and transpiration. Then there are palisade and spongy tissues which are actually parenchyma cells having chloroplast They synthesise food Then again, there are vascular tissues : the xylem for the conduction of water and minerals, and the phloem carrying the prepared food Almost all the plant tissues are found in a leaf

What are the functions of a stem ? It gives support to the plant (Fig 6.3) and holds the leaves, flowers and fruits. The sclerenchyma and xylem tissues do this function.

The other function of the stem is conduction. The water and minerals absorbed by roots are conducted to the leaves, and the prepared food from the leaves is transported to other parts through the stem. The vascular tissues are responsible for this function

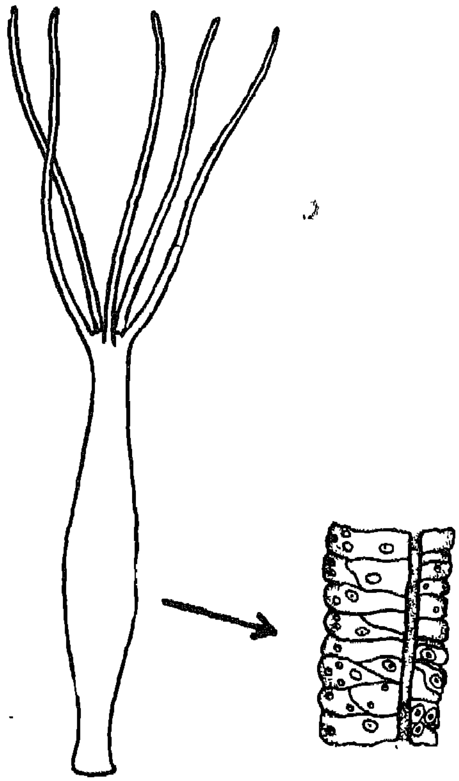


Fig. 6 2 *Hydra* is an animal with a tissue level of organisation The arrow shows the two layers of cells which constitute the body wall of the organism

In addition to these functions, stems in certain plants like sugarcane and ginger store food. In some plants (opuntia, cactus, etc.), the stems synthesise food.

The root is another organ of the plant body. The general pattern of organisation of different tissues in roots is the same as that in the stem. As you know, the root absorbs water and dissolved minerals from the soil Such absorption takes place only in the root hairs.

Roots hold the plant in the soil. To do this, the roots go deeper into the soil and spread in all directions They also have strong conducting elements which provide strength for proper anchorage. Some plants like carrot and radish store food in their roots.

ORGANISATION AT THE ORGAN SYSTEM LEVEL

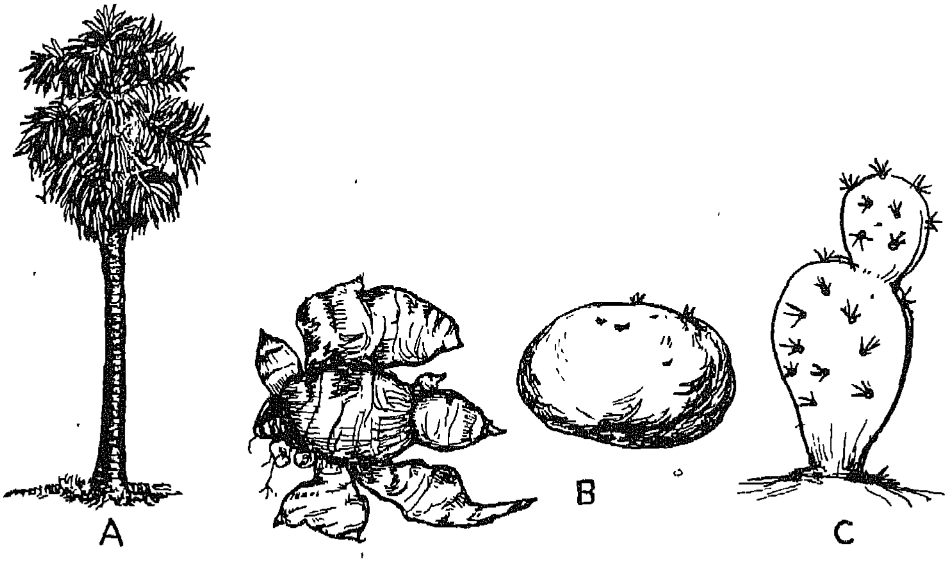
Various organs of the plant body are organised into organ systems. Collectively, all the organs of a system perform a major function of the organism. In plants, there are only two organ systems . the shoot system and the root system (Fig 6.4).

You know how the body of a plant is organised at the level of organs and organ systems The organisation of the body in higher animals is still more complex and well defined.

Let us examine the external and internal parts of the body of a higher animal, say, a frog.

EXPERIMENT

1. Take a chloroformed frog on a dissection tray; place it in such a way that its ventral part faces you.
2. Fix the animal on the tray by pinning its out-stretched limbs. The pins should be fixed inclining towards the outer side
3. With a pair of forceps and a pair of blunt scissors gradually proceed with an incision along the midventral line
4. Give another careful incision along the



6 3. Stem of a plant may have several functions : A. Support and conduction; B. Storage and C. Food synthesis.

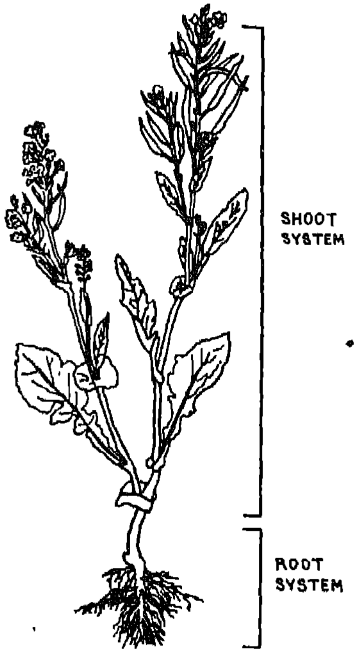


Fig 6.4. Plants have only two organ-systems—root system and shoot-system.

midventral line to cut open the ventral muscle layer to open the viscera.

5. Remove the skin and ventral muscles to have a full view of the viscera.
6. Identify the different organs of the viscera (Fig. 6.5) and try to determine the functions of the heart, lungs, liver, stomach, intestine, kidney and testis (or ovary).
7. With the help of your teacher, dissect out the alimentary system (Fig. 6.5).
8. Make a labelled sketch.

COMPLEX ORGANISATION IN ANIMALS

In different groups of animals, from worms to man, there is a progressive increase in the complexity of body organisation. A series of organs and organ systems have evolved to serve the various needs of the organism (Fig 6.6). These are :

1. The integumentary system, consisting of skin and its derivatives, mainly ser-

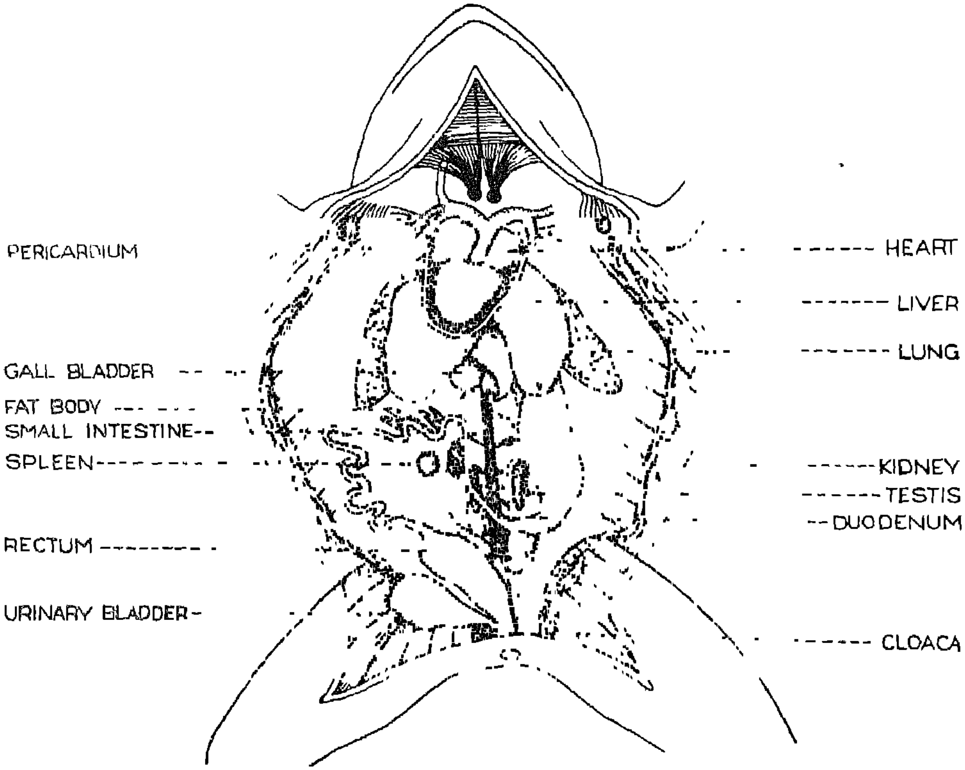


Fig 6 5 The general viscera of a frog showing the position of different organs.

ves to protect the organisms from the environment.

2 The skeletal system, consisting of bones and cartilages, mainly supports and protects the body.

3 The muscular system is responsible for movement and locomotion.

4. The alimentary system performs nutrition

5 The circulatory system is for the internal transport of material

6 The respiratory system is for breathing or gaseous exchange

7 The excretory system is for the removal of metabolic wastes (other than of respiration) and excess fluid.

8 The endocrine system, consisting of hormone-secreting ductless glands, serves to regulate internal processes and adjusts to the outer environment

9 The nervous system, consisting of the brain, nerves and sense organs, coordinates the internal organs and responds to the external stimuli

10. The reproductive system, consisting of male or female sex organs, carries out reproduction.

In many of the invertebrates and all the vertebrates these systems are present In some animals, the life functions are carried out without some special systems being present For example, flatworms and roundworms lack the respiratory and circulatory systems.

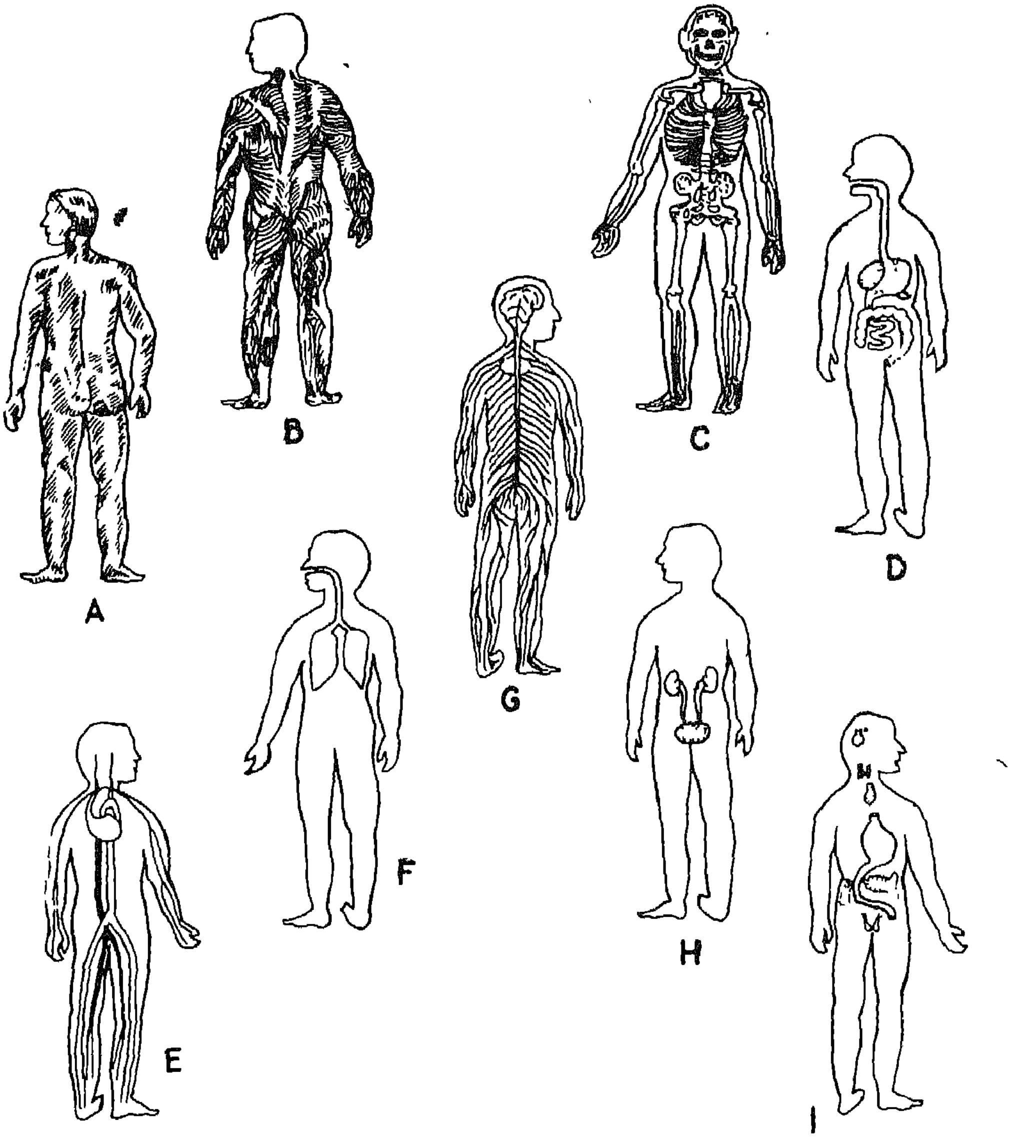


Fig. 6 6 Different organ systems of man

A Integumentary system, B Muscular system, C Skeletal system, D Alimentary system E Circulatory system, F. Respiratory system, G Nervous system, H. Excretory system and I Endocrine system

TEST ITEMS

1. What are the different organelles in the body of an amoeba ?

2. Fill up the gaps :
   (i) Amoeba ingests food by______________
   (ii) Paramoecium ingests food by______________
   (iii)______________have only one kind of tissue
   (iv) The ectoderm of hydra is______________and the endoderm is _____

3 What are the different functions of a root ?

4. Draw and label the general viscera of a frog.

5. Name the important organ systems of man.

CHAPTER 7

Tissues in Plants and Animals

1 There is a division of labour within a multicellular body
2 The cells which have a similar origin, structure and function constitute a tissue
3. There are four major kinds of tissues in plants.
4. There are five major kinds of tissues in animals.
5 The tissues, which cover the animal body die periodically and are replaced by new tissues

In a unicellular organism all the life processes are carried out within the single-cell body But in multicellular organisms all the cells do not take part in all the life processes There is a division of labour On the basis of their functions, the cells have different structures The group of cells having similar origin, structure and function are called *tissues* There are several kinds of tissues in plants and animals

PLANT TISSUES

The plant tissues (Fig 7.1) are classified as follows:

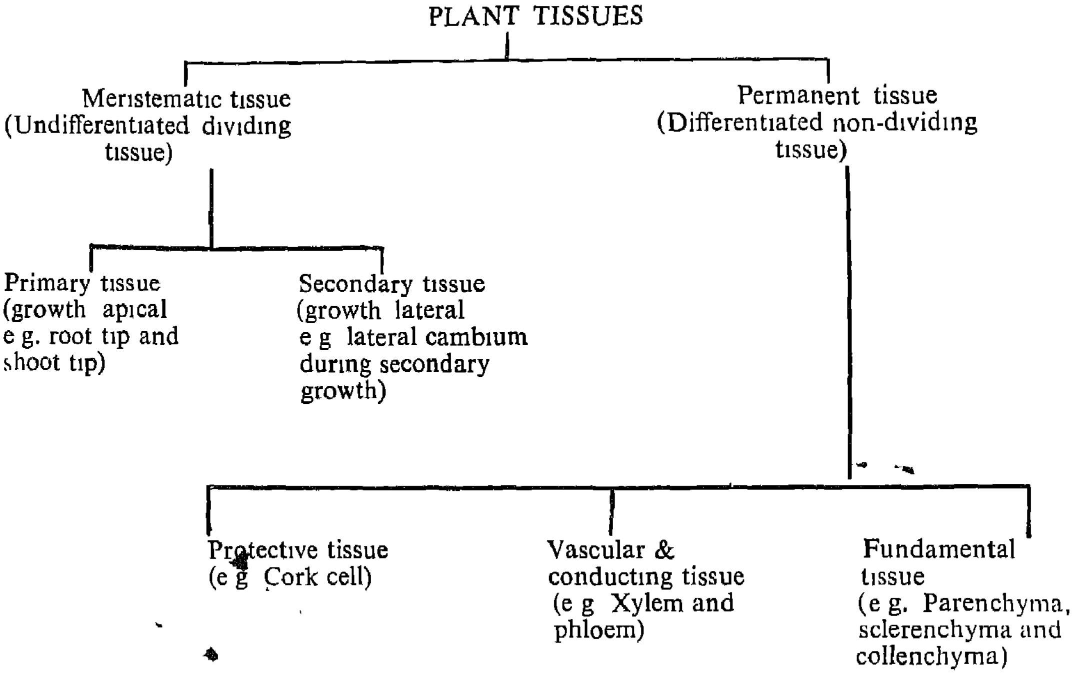
MERISTEMATIC TISSUE

Examine the prepared slide showing the section of a *root tip* under microscope (Fig 7.2). Draw the cells of the different regions and label it Note that most of the cells in this region are thin-walled and unspecialised As the root tip is the growing region, you may find that many cells are in divisional stages All these cells constitute the *meristematic tissue* or *meristem* Such a tissue is present only in the growing regions like the shoot tip, root tip and cambium (region which is responsible for growth in thickness). The cells of this tissue change into other types of tissue.

PERMANENT TISSUE

Protective Tissue. These tissues are usually present in the outer most layers of the plant body and protect the inner tissues

The cells of these tissues may be specialised


PLANT TISSUES
Meristematic tissue (Undifferentiated dividing tissue)
Permanent tissue (Differentiated non-dividing tissue)
Primary tissue (growth apical e g. root tip and shoot tip)
Secondary tissue (growth lateral e g lateral cambium during secondary growth)
Protective tissue (e g Cork cell)
Vascular & conducting tissue (e g Xylem and phloem)
Fundamental tissue (e g. Parenchyma, sclerenchyma and collenchyma)

in various ways. In onion skin, you will find that the cell walls are thick and waterproof by the addition of certain organic compounds like suberin. The bark of a tree is formed by layers of such specialised cells called *cork cells*. These cells which are dead, have heavily thickened walls.

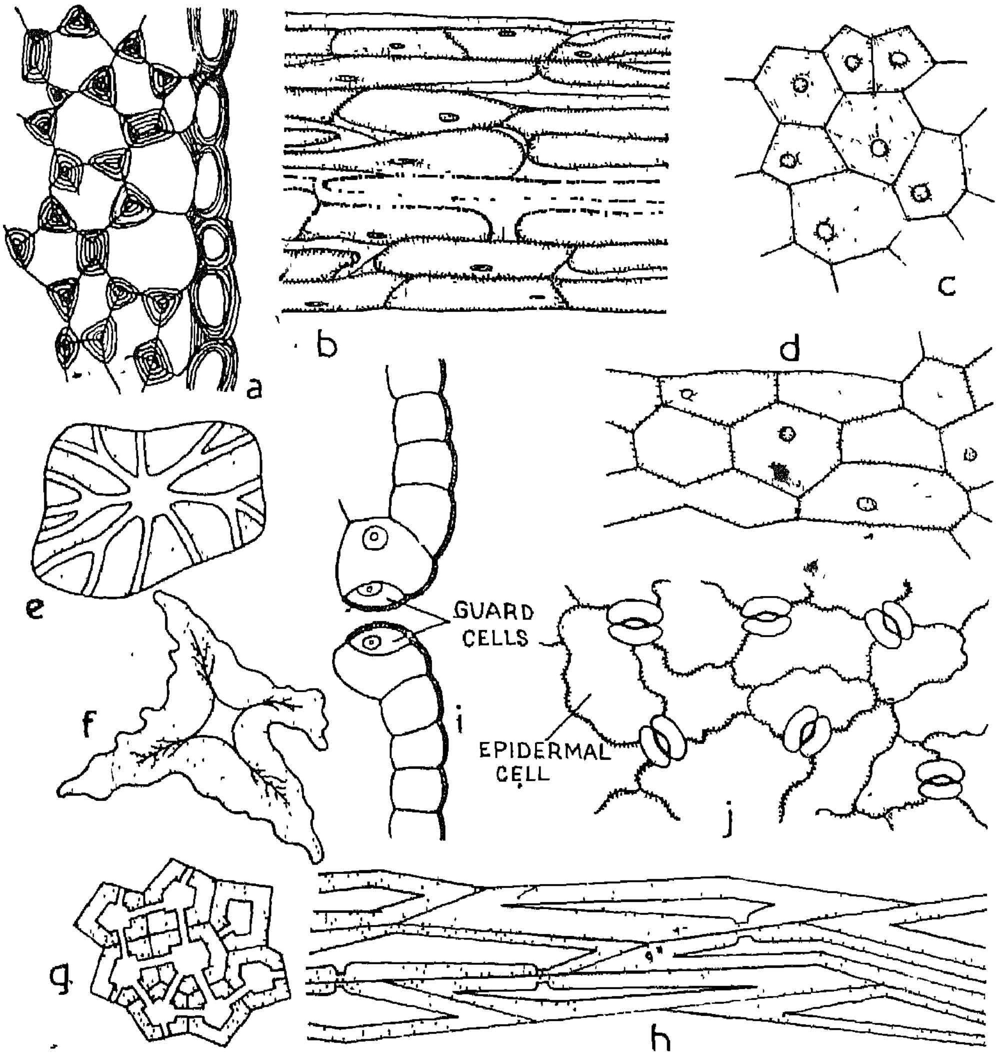
EXPERIMENT

Take out a thin layer from the lower surface of a leaf Mount it on a slide in water Examine it under the microscope. You will find some of the epidermal cells have become specialised into thick walled crescent-shaped structures These are always in pairs, and their concave sides face each other These are called guard cells and the space in between is known as stomatal opening

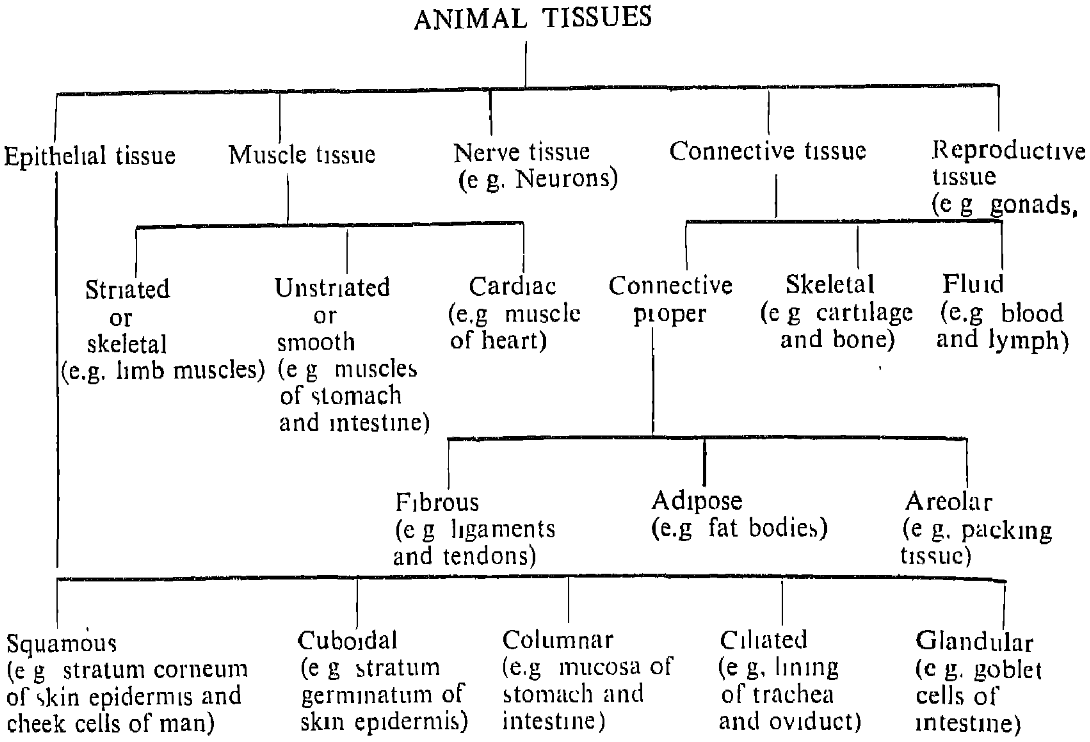
Vascular or Conducting Tissue. Look at Fig. 7.2(B) which shows the transverse section of a dicot stem. You may make a transverse section of the dicot stem and examine it under the microscope. Note the cells in the xylem and phloem region. These two regions are made up of two types of vascular tissues of a plant. The dead and thick-walled xylem is mainly composed of tubular vessels which carry water and minerals from the root to the different parts of the shoot.

The phloem is made up of several kinds of cells, the most important of which are the sieve tubes These tubular cells have perforated walls to allow the flow from one cell to the next Unlike xylem, phloem is a living tissue

Fundamental Tissue These tissues consist of the least specialised cells of a plant body Examine Fig. 7.2 which shows the transverse sections of root and leaf. The fundamental tissue is present in the root, stem, leaf as well as in flowers and fruits There are three kinds of fundamental tissues *parenchyma*, *collenchyma* and *sclerenchyma*. The parenchyma cells are



ig 7.1. Different kinds of tissues in plants :
a. Collenchyma-cross-section; b Collenchyma-longitudinal section; c. Parenchyma cross-section, d Parenchyma longitudinal-section, e. Sclerenchyma fibres-cross section; f. Sclerenchyma-complete sclereid g Section of sclereid, h Sclerenchyma-longitudinal section; i Guard cells in a leaf, j. Epidermis of a leaf.


ANIMAL TISSUES
Epithelial tissue
Muscle tissue
Nerve tissue (e g. Neurons)
Connective tissue
Reproductive tissue (e g gonads,
Striated or skeletal (e.g. limb muscles)
Unstriated or smooth (e g muscles of stomach and intestine)
Cardiac (e.g muscle of heart)
Connective proper
Skeletal (e g cartilage and bone)
Fluid (e.g blood and lymph)
Fibrous (e g ligaments and tendons)
Adipose (e.g fat bodies)
Areolar (e g. packing tissue)
Squamous (e g stratum corneum of skin epidermis and cheek cells of man)
Cuboidal (e g stratum germinatum of skin epidermis)
Columnar (e.g mucosa of stomach and intestine)
Ciliated (e g. lining of trachea and oviduct)
Glandular (e g. goblet cells of intestine)

thin-walled and are seen as palisade and spongy tissues of the leaf and are also seen in the pith and cortex of the stem and root. The collenchyma cells are thick at the corners The developing leaves and cortex of the tender stems have collenchyma The sclerenchyma cells are extremely thick-walled and provide mechanical support Some sclerenchyma cells may be dead They help the plant, when the wind or other forces bend it, to prevent the tearing of its body

ANIMAL TISSUES

Cells are organised into five types of tissues in higher animals including man.

They are. *epithelial tissue*, *muscle tissue*, *nerve tissue*, *connective tissue* and *reproductive tissue.*

EPITHELIAL TISSUE

They form a continuous layer of the entire body surface and its inner cavities The skin, surface layers of mouth, alimentary canal and lungs are made of epithelial tissues

The cells of the epithelium (Fig. 7 3) may be flattened (*squamous epithelium*), cubical (*cuboidal epithelium*) and pillar-like (*columnar epithelium*) Some of them have protoplasmic hair-like structures on their external surface (*ciliated epithelium*). Examine the prepared slides under microscope and study the structure of epithelial tissue

What are the functions of this tissue? You all know how painful it is when soap, salt or chilly-powder comes into contact with a cut or wound on your body. And you have also noticed that a small cut on your skin, unless it is properly dressed, allows harmful bacteria to get into it easily resulting in inflammation So on the external surface, this tissue, which forms the outer layer of skin, protects the underlying cells from drying, injury, bacteria and chemicals

Inside the body, besides protecting the organs, the epithelial tissues absorb water and other nutrients and also eliminate waste products.

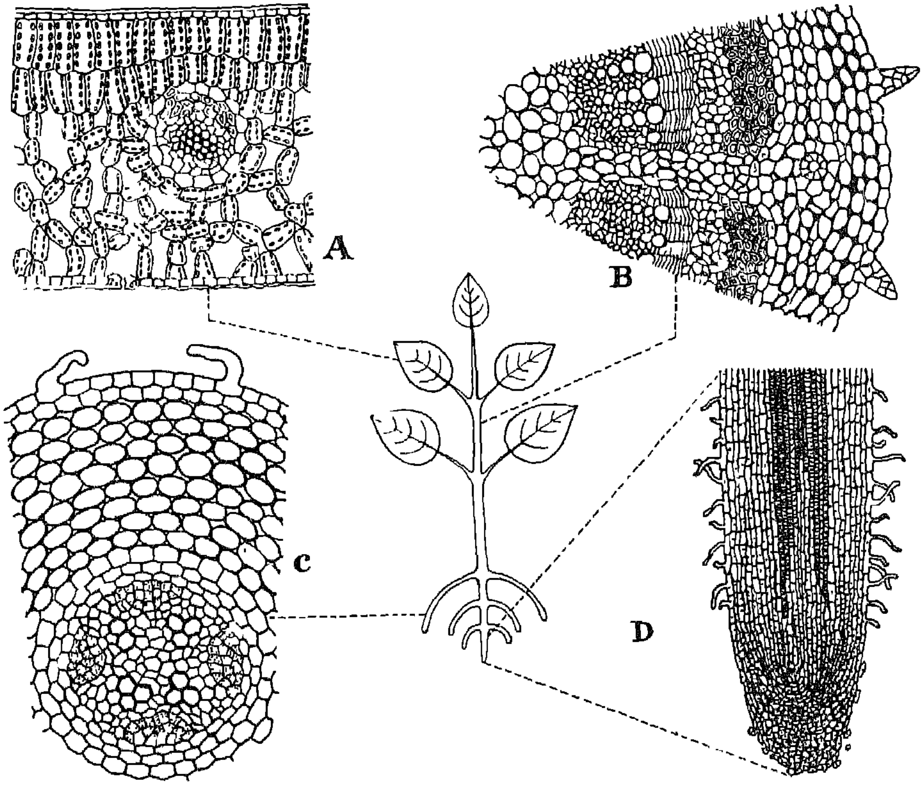


Fig 7 2. Internal organisation of various parts of a growing plant : A Leaf ; B. Stem , C. Root and D Root tip

Some cells of the epithelium are greatly specialised and are secretory in function. Such cells are termed as glandular epithelial tissues. Ear-wax, mucus, milk and digestive juices are some of the secretions of such tissues

MUSCLE TISSUES

You have learnt that the ability to move the whole body or a part of the body is an important animal character The movement is brought about by a group of cells. These cells contract and relax, responding to different stimuli, and can effect movement. The movements of the heart and alimentary canal are all caused by muscle tissues. The major part of the body weight is due to the muscles.

There are three types of muscle tissues (Fig 7 4) The skeletal muscles are formed of one type The cells of this muscle tissue are long and multi-nucleated. Under a microscope you can see stripes across such muscle cells The skeletal muscles are attached to bones and they help move the body and its appendages. Examine a prepared slide of skeletal muscle and compare it with Fig. 7 4

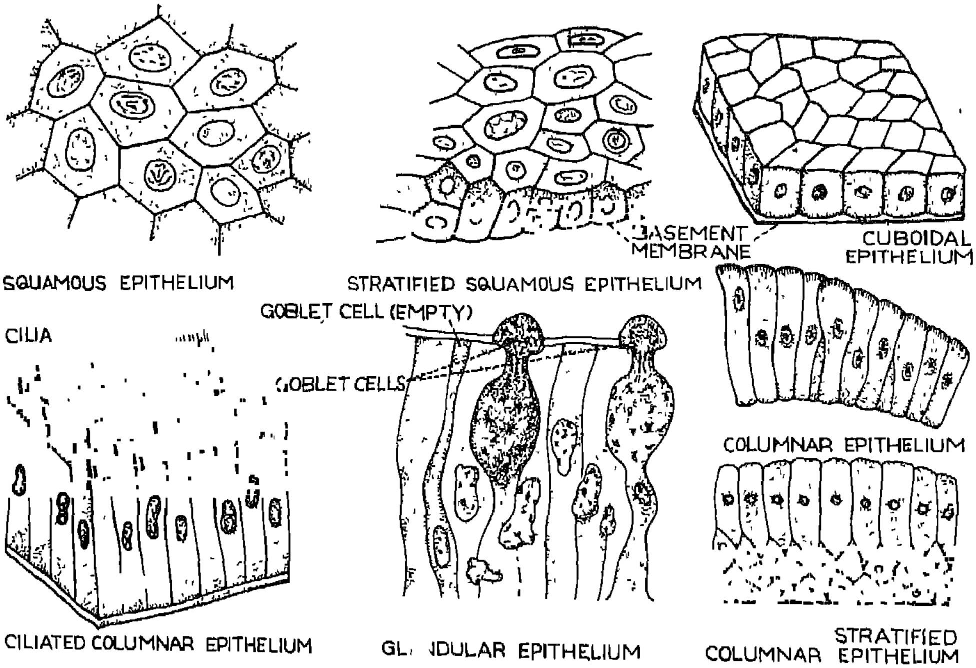


Fig 7 3. Different types of epithelial tissues

Another type of muscle cells constitutes the heart muscles or cardiac muscles. Like the skeletal muscles, they are striated and multi-nucleated. But cells of cardiac muscle tissue branch out and fuse with one another. Examine a prepared slide of cardiac muscle Note how it differs from other muscles

The third type of muscle cells are long with pointed ends The cells are uni-nucleated and unstriated. These are called smooth muscles The smooth muscle tissues are found within the walls of stomach and intestine

NERVOUS TISSUE

It is a collection of cells specialised to conduct impulses The cells are called *neurons* As you see in Fig. 7 5, the neurons have a peculiar structure Brain, spinal cord and nerves are all composed of nervous tissues.

CONNECTIVE TISSUE

It is composed of cells embedded in a non-living matrix (or medium). The cells are usually separated from one another by varying amounts of intercellular space This space is

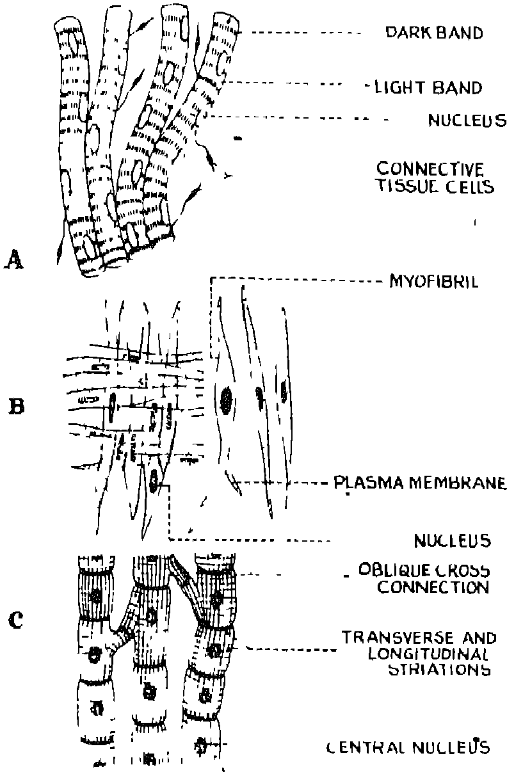


Fig 7 4. Different types of muscle tissues A. Skeletal muscle fibres ; B Smooth muscle fibres and C Cardiac muscle fibres

filled with solid or fluid materials, forming a matrix Fig 7 6 shows different kinds of connective tissues

Bone, cartilage, tendons and ligaments are examples of connective tissue They connect different tissues of the body and give the body the necessary support

The cartilage is somewhat flexible. The skeleton of the outer region of nose and ear are made of cartilage In some animals like shark the whole skeleton is cartilaginous.

Unlike the cartilage, the matrix of the bone is heavily coated with calcium salts Hence the bones are very strong and non-flexible.

Examine the prepared slides of cartilage and bone under microscope and draw the diagrams You must remember that cartilage and bone contain living cells and that they are supplied with nutrients.

Tendons and ligaments are connective tissues Here the matrix is a thick network of fibres. These fibres are secreted by surrounding connective tissue cells.

The tissues that bind muscle cells together and connect skin with the underlying muscle are also examples of connective tissue Here the fibres are loose and very elastic

Blood is also a connective tissue, where the cells move in a fluid medium called blood plasma You have already learnt the functions of blood It flows to all parts of the animal body and thus connects every part of the body. Perhaps it is the most connective of all tissues.

REPRODUCTIVE TISSUE

It consists of specialised cells which are set apart at a very early stage of development from the somatic (body) tissue cells These cells constitute the germ cells, which multiply and ultimately give rise to the sperms (male gametes) in the males and ova (female gametes) in the females The divisions of germ cells which result in the formation of sperms and ova are known as maturation (reduction) divisions.

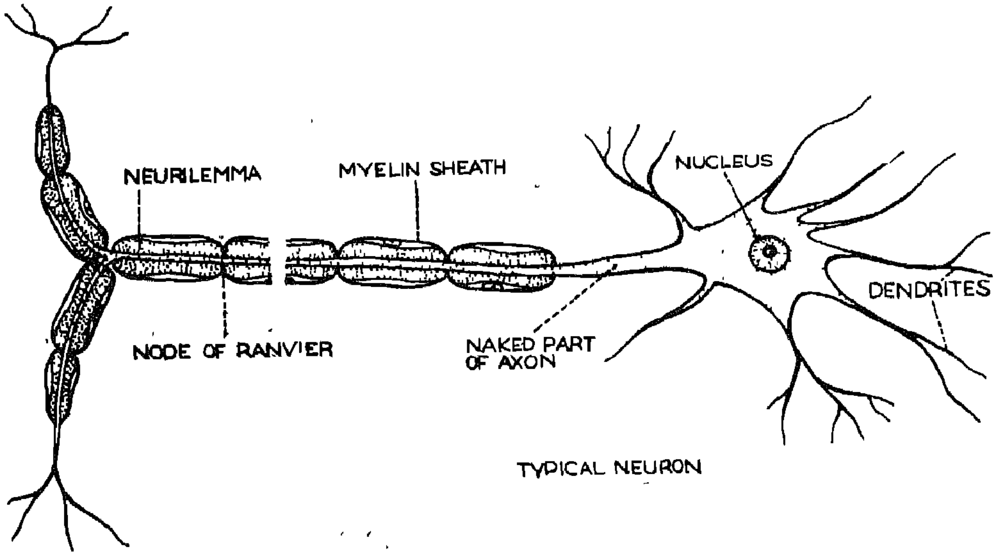


Fig 7 5 Diagram of a neuron

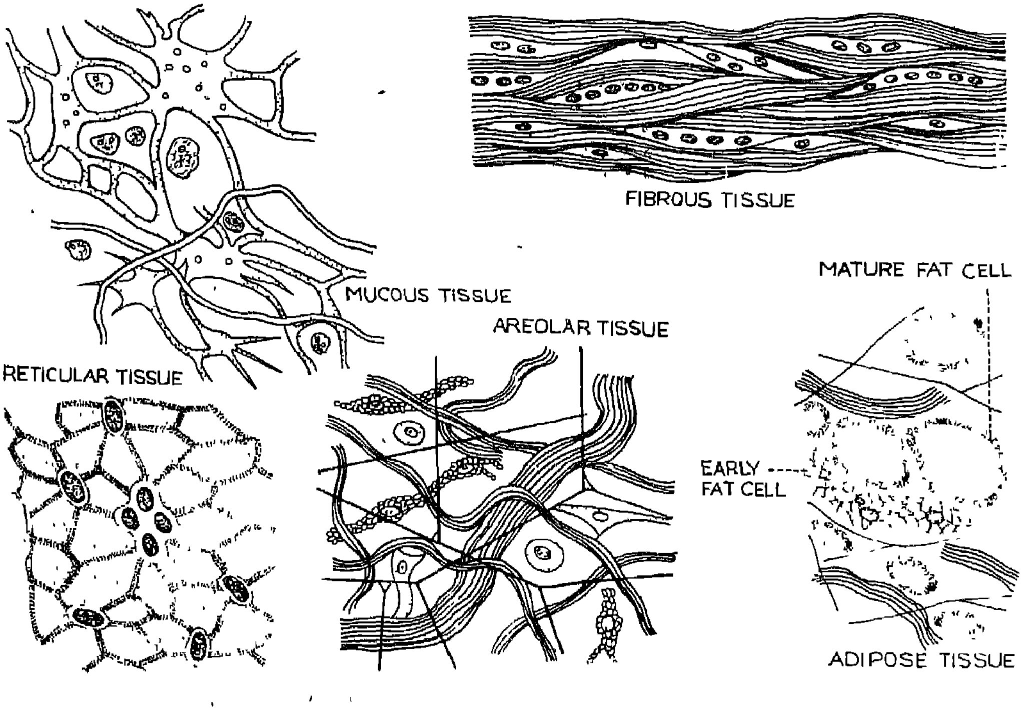


Fig. 7 6. Different kinds of connective tissues.

TEST ITEMS

1. Where do we find the meristematic tissue? What is the chief characteristic of this tissue?
2. Most of the higher plants contain a lot of dead tissues —
   Give the names of such tissues
3. What are the differences between the collenchyma and sclerenchyma tissue?
4. What are the different types of animal tissues?
5. What are the differences between a cartilage and a bone?

CHAPTER 8

Cell: Structure and Functions

1. Cell is the unit of all living beings
2. Our knowledge of the cell has grown with the development of new equipment and techniques
3. The cell concept of today is the result of contributions from a large number of scientists from different parts of the world
4. The body of a unicellular plant or animal is made up of a single cell.
5. The structures and functions of the different parts of a cell (called cell organelles) are basically same in all organisms

CELL THEORY

IT took several generations of scientists to know the nature of cells and understand their role in the living system. The progress in this field went hand in hand with the improvement in the magnifying and resolving powers of the microscope.

Long ago, in the year 1665, an English scientist Robert Hooke cut slices of cork and placed them under his newly made microscope. He noted that this material was composed of numerous tiny compartments to which he assigned the name *cells*. But it should be remembered that Hooke's microscopical studies were stimulated by earlier findings of the Italian scientist Galileo (about 1610) and the Dutch scientist Anton van Leeuwenhoek (A D 1632-1723) who had themselves made crude microscopes and seen living structures through them.

After Robert Hooke's discovery of the cell, it took almost 200 years for the formulation of the cell theory It was in the year 1838 that the 'cell theory' was enunciated by two German scientists, Mathias Jacob Schleiden and Theodor Schwann. It simply stated that all plants and animals are composed of cells and all cells come from the pre-existing cells For the last three decades, new experimental tools such as ultracentrifuge, electron microscope, phase contrast microscope, etc , have been employed to look into the internal structures and understand the functional significance of cells This has led to the discovery of more details of cell structures which had never been imagined before

EXAMINATION OF PLANT AND ANIMAL CELLS

EXPERIMENT I

1. Take a clean and sterile toothpick, scrape with it the inside surface of your cheek
2. Take the scrape on a clean slide and rub it gently
3. Add one drop of water in the mass of scrape.
4. Try to separate individual cells with the help of two needles
5. Add a drop of 0.5 per cent aqueous solution of Janus Green and wait for 2 minutes
6. Put the coverslip and observe under the low power of microscope
7. Switch to high power and note the contents of the cells
8. Draw and label (Fig. 8.1)

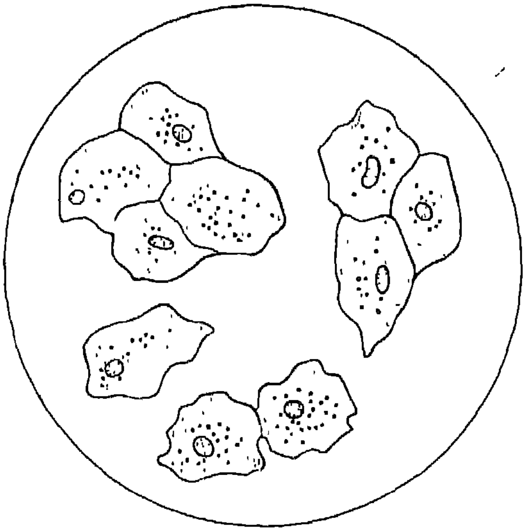


Fig 8 1. Cheek epithelial cells under microscope

EXPERIMENT II

1. Take a shoot of the water plant *Hydrilla* or *Elodea*.
2. With fine-pointed forceps pluck a young leaf from the tip.
3. Quickly mount it on a clean slide in water
4. Observe the cells under low power and carefully choose a cell in which you can see green dots moving
5. Switch to high power, note the internal structures of the cells and the streaming movement of the cytoplasm
6. Draw and label (Fig. 8.2).

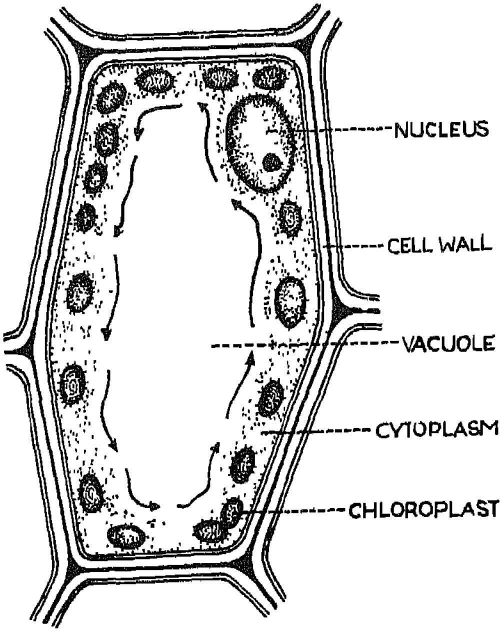


Fig. 8 2. Cell of a *Hydrilla* leaf. The arrows indicate the direction of cytoplasmic movement

STRUCTURES OF CELLS

You have now examined, drawn and identified cells of animals and plants. You have also noted that the cells of different organisms as well as those of a single multicellular organism differ in size, shape and internal structure.

The cell is bound by a very delicate and elastic membrane forming its outer surface known as the *cell membrane* or *plasma membrane*. It is selectively premeable. Plasma membrane selectively permits the entry of some substances into the cell and allows the flow of some substances out of the cell. Besides protecting the internal structures, it also helps maintain the internal environment of the cell in a desired state Plant cells have a rigid, non-living *cell wall* made up of cellulose outside the plasma membrane. The cell wall of plant cells is protective and it largely determines the shape of the cell (Fig. 8.3).

Inside the cell membrane, there is a viscous, transluscent, jelly-like substance filling almost the whole of the interior of cell This is known as *cytoplasm* It contains a number of small bodies and particles embedded within it. Some of these are active sites of the vital functions of the cell. They are known as *cell organelles* Other cell inclusions are the products of metabolism, like sugars, fat globules, starch, glycogen, secretions as well as many other organic and inorganic materials The cytoplasm also has one or more vacuoles which seem to be empty, but really are filled with watery liquid. Vacuoles are usually small and few in animal cells, but are large and numerous in plant cells.

The cell also contains a comparatively dense, prominent and round or oval body called the *nucleus*.

Just outside the nucleus is a globular *centrosome* with one or two dot-like *centrioles* and numerous radiating refractile and extremely fine fibres—the *astral rays. The centrosome does not occur in plant cells.*

Among the important cell organelles in the cytoplasm are the *mitochondria*. These are minute rod-shaped, fibre-like, granular or globular bodies. Mitochondria are concerned with respiration of the cell. In the cytoplasm are also

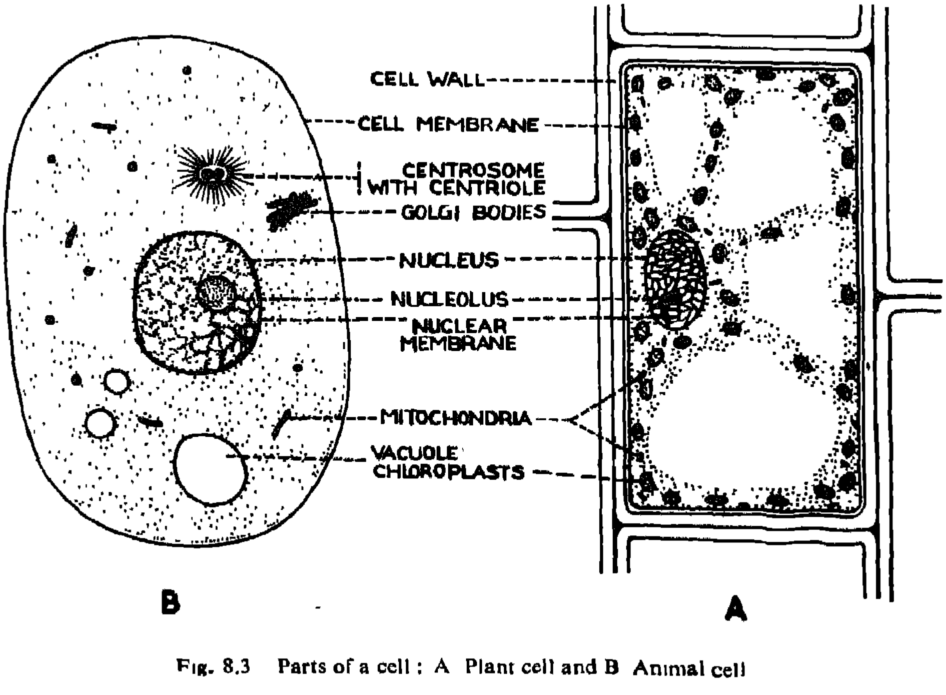


Fig. 8.3 Parts of a cell : A Plant cell and B Animal cell

found small groups of fine sacs known as *golgi apparatus* (in animal cells) or the *dictyosome* (in plant cells) These are believed to have a role in secretions.

A group of small granular organelles occur exclusively in plant cells; they are known as *plastids.* Of these, the most important is the *chloroplast* or green plastid. Chloroplasts are concerned with the trapping of energy from sunlight and the synthesis of carbohydrates

The colourless plastids are the *leucoplasts* which have a role in the storage of food. The plastids, coloured other than green (red, yellow), or the *chromoplasts*, are responsible for the colour of flowers, fruits and seeds.

Some cells (sperm cells) and unicellular organisms such as *Euglena* move with the help of a protoplasmic whip-like structure known as *flagellum* In the body of *Paramoecium* and several other cells there are small hair-like cilia with similar function.

The nucleus of the cell usually is spherical or oval, but in some cases, it may be elongated or lobed. The nucleus may be at the centre of the cytoplasm or pushed to one side of it The nucleus controls much of the cell metabolism. If the nucleus is removed, a cell fails to perform anabolic activities and lives only for a limited period An isolated nucleus, of course, cannot form cytoplasm. Like the cell, nucleus also has an outer limiting membrane known as the *nuclear membrane.* It encloses the liquid content of the nucleus known as *karyolymph* or *nuclear sap.* The most important structures within the nucleus are the *chromatins.* They look like isolated granules which are actually parts of continually spiralled filaments During the cell division, the chromatins occur as distinct and visible threads They are called *chromosomes.* The chromosomes contain linearly arranged genes which are regarded as the bearers of hereditary characters. Each nucleus contains

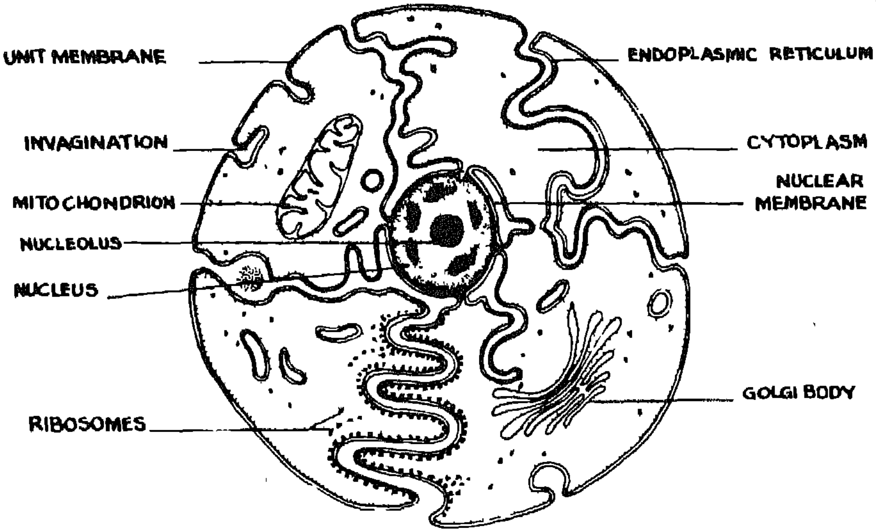


Fig. 8.4. The schematic diagram of a cell as seen under the electron microscope.

usually one (or more) spherical bodies called *nucleolus*. The nucleolus contains large amount ribonucleic acid (RNA).

CELL AND CELL ORGANELLES AS SEEN UNDER THE ELECTRON MICROSCOPE

The electron microscope enables us to have a much clearer and detailed picture of the extremely small cell organelles. Now, you try to understand from the electron micrograph (Fig. 8 4) the structural nature of the organelles.

The *cell membrane* is almost invisible under the light microscope. Under the electron microscope, the cell membrane shows three layers. A white layer is sandwitched between two dark layers. The dark layers are of protein, while the white layer is made up of lipid molecules Besides the membrane surrounding the cell there are several kinds of membranes in the cell, all of which are of similar nature

The cytoplasm is not a uniform mass. It is filled with membranes and particles In many cells, conspicuously long membranes pass through the cytoplasm, forming many channels. These are known as *endoplasmic reticulum* In some cells, these membrane bound canals are sparse or even absent. In some cells, the membranes are smooth, in others they are rough The roughness of these membranes is due to the presence of some granules called *ribosomes*. Some of the membranes of the endoplasmic reticulum open on the plasma membrane, and the others on the nuclear membrane. The endoplasmic reticulum helps in the transport of materials through the cytoplasm. The ribosomes attached to it carry out protein synthesis. The endoplasmic reticulum increases the surface area for cellular activities.

The *golgi bodies* appear as a group of sacs or balloons bunched together. They seem to accumulate certain materials such as fats, mucus or some secretory substances and then they push them out of the cell.

The *mitochondria* are seen as double-walled bags They have outer and inner membrane walls. The inner membrane is thrown in transverse shelf-like folds known as *cristae*. The cristae help increase the surface area The mitochondria contain several respiratory enzymes which are concerned with energy release. They also contain the Deoxyribonucleic acid (DNA).

Inside the cell, there are also some minute cell organelles called *lysosomes*. They are similar in appearance to the mitochondria and are without the cristae

If for some reasons the lysosomes disintegrate they liberate enzymes which cause the breakdown of the cytoplasm and kill the cell. They are, therefore, called 'suicide bags'

The nucleus of the cell is enclosed in a double membrane. The nuclear membrane is porous and is connected with the endoplasmic reticulum. The nuclear membrane is very similar to the cell membrane in structure. It forms a barrier between the nuclear content and the cytoplasm Unlike the cell membrane, the nuclear membrane can disappear and reappear during the cell division. It also shows selective permeability.

The *plastids*, specially the chloroplasts, are very important cell organelles of the green plants. The structures of these chloroplasts are very complex They are bags stacked with many layers of membranes (layers of proteins and lipids), These membranes are known as *grana*. The ground substance of the grana is known as *stroma*.

The green-pigment molecules (*chlorophyll*), which trap the energy of sunlight, are arranged in the grana. The leucoplasts, which are concerned with the storage of food are devoid of the grana layers.

The centrioles appear under the electron microscope as a cylinder made up of nine filaments arranged in a ring.

CELL DIVISION

The self-duplication is the most important feature of the living substance This function is carried out by the process called cell division. There are two important types of cell division · (1) *mitosis* and (2) *meiosis*.

MITOSIS

The word *mitosis* means division of the nucleus, but it is used to describe both the division of the nucleus and cytoplasm The production of two cells by mitosis is the climax of an extensive series of events (Fig 8.5) which are blended into one another.

Just before the division of the cell, the cell prepares for the change. This is known as the 'interphase'.

The process of mitosis is divided into five stages—prophase, metaphase, anaphase, telophase and cytokinesis All these stages are parts of a dynamic process The time necessary for the completion of each stage or of the entire process varies in different cell types and depends upon various physical and chemical factors.

Prophase. During the prophase, the chromosomes become visible. Each chromosome is already duplicated into two *chromatids* But the two chromatids remain united together and attached to one region. The region of attachment is called *centromere*.

In the animal cells, the centrosome, containing centriole, splits into two The daughter centrioles move apart and each occupies one pole of the cell At each pole, the cytoplasm around the poles becomes a *gel* and forms a star-like structure. This is called *aster.* In the cytoplasm, in between the two daughter centrioles, a number of fibres appear. These are called *spindle fibres*. In plant cells also, the spindle fibres appear, though the centrioles are absent.

At the end of the prophase, the nuclear membrane and the nucleolus disappear and the chromosomes move towards the equator of the cell.

Metaphase. This is a brief stage when the chromosomes complete arranging themselves on the equatorial plane.

Anaphase. At this stage, the two chromatids of each chromosome separate. Each chromatid moves towards the opposite poles

Telophase. Each chromatid or daughter chromosome, after having reached closer to the poles, turns into a network of chromatin threads Then the nuclear membrane reappears. This is also followed by the reappearance of nucleolus in each daughter nucleus.

Cytokinesis The division of the cytoplasm starts from the anaphase stage. At the end of the telophase, a furrow appears in the cell membrane along the equator As the furrow deepens, a considerable movement of the cytoplasm takes place The cell finally splits into two along the line of the furrow The cytoplasmic movement ceases with the split.

The mitosis is the mode of reproduction in many unicellular organisms. The growth and development of multicellular organisms also depend upon the process of mitosis. It plays an important role during the healing of a wound, regeneration and normal wear and tear of the individual.

Though the process of mitosis is understood, it is not known what stimulates the phenomenon We only know that it depends upon the metabolic activities of the cell and it does not usually occur in cells which have attained specialisation.

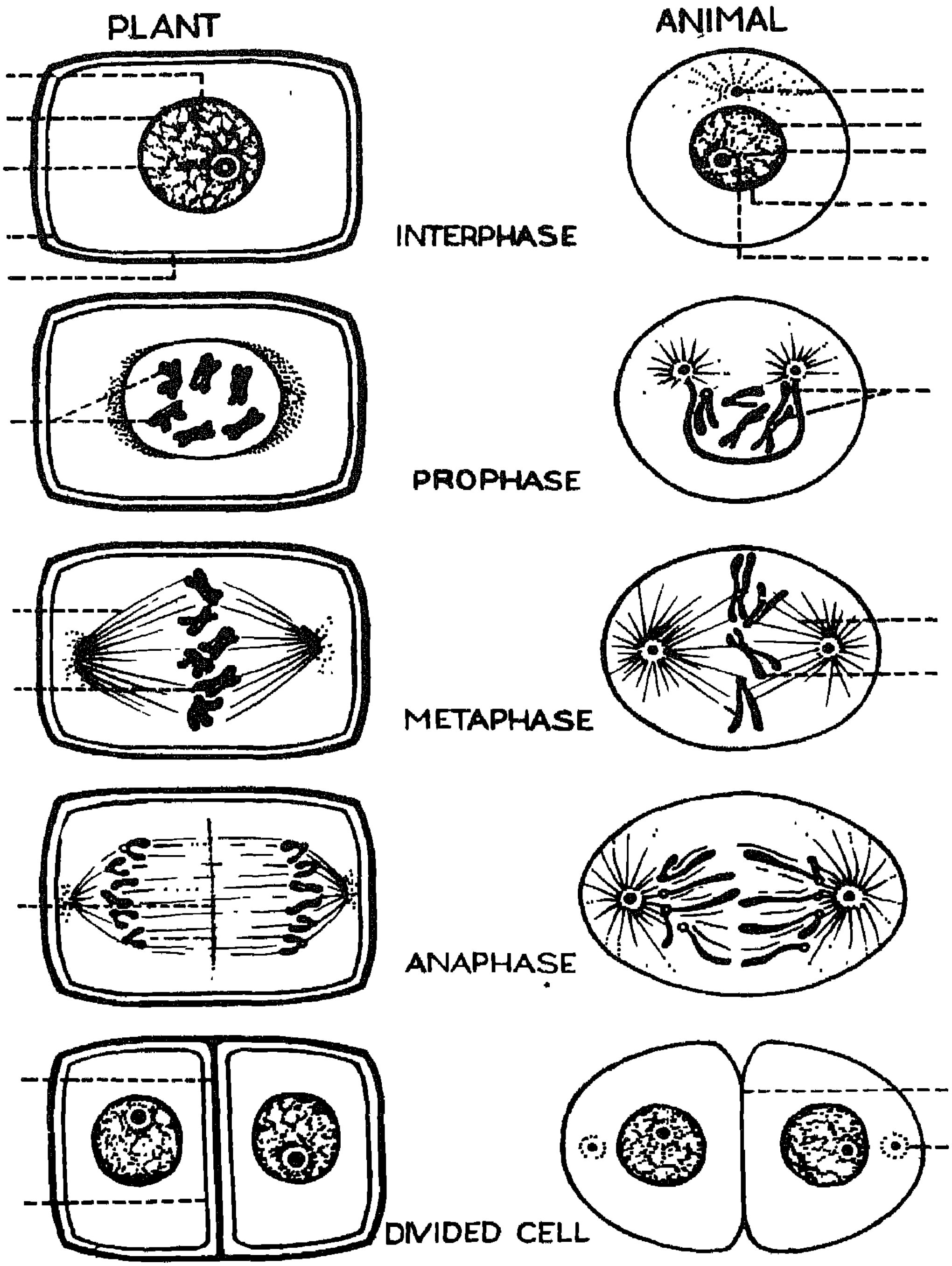


Fig 8.5. Mitosis in plant and animal cells Label the different parts of the dividing cells.

MEIOSIS

In all living organisms, the chromosomes are in pairs The number and appearance of the chromosomes are same within a species. The forms, which reproduce asexually, usually duplicate by mitosis Thus, there is no chance in the alteration of the number and appearance of the chromosome. But in sexually reproducing forms like man, two individuals contribute one cell each (egg cell from the female and sperm cell from the male) These two cells fuse and develop into a new individual If these two cells were produced by mitosis, then in the daughter individual the chromosome number would have been doubled. This 'doubling' would continue in successive generations. But still, man has only 23 pairs of chromosomes This has been possible because of a special kind of cell division called meiosis (Fig 8.6). It occurs

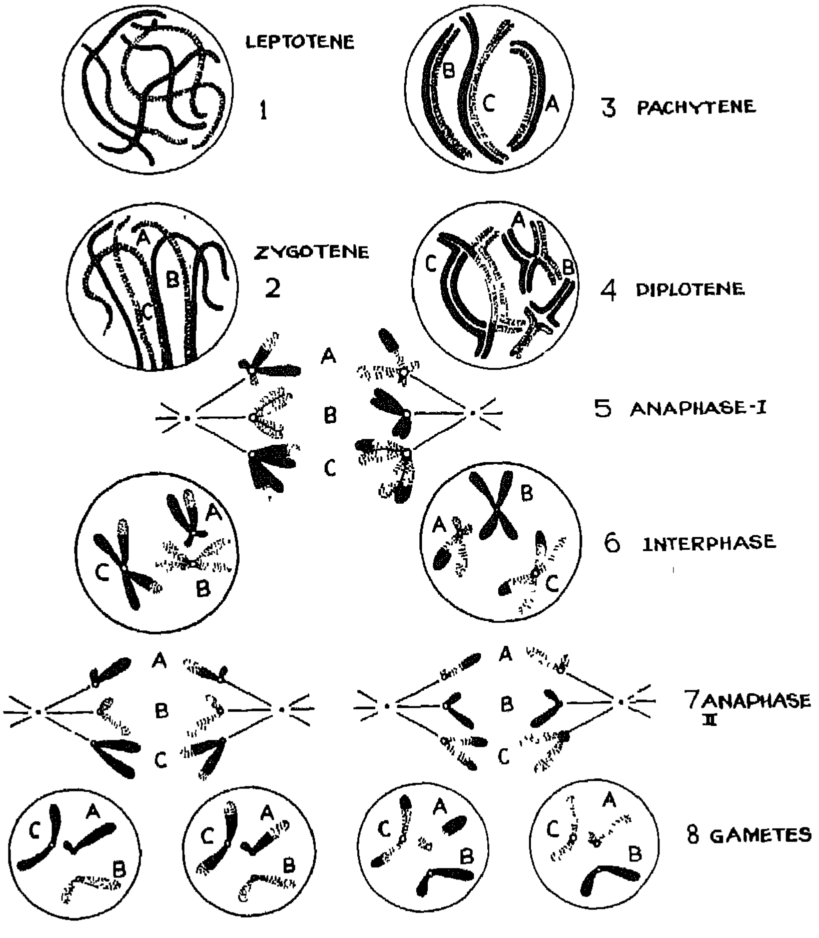


Fig. 8 6 Different phases of meiosis or reduction division 1—5. First Division, 6 Interphase and 7. Second Division only in the reproductive organs The reproductive cells first undergo a *reduction division* (*first meiotic division*) In this division, not the chromatid but one chromosome (two chromatids) is separated from its corresponding pair Thus two cells are formed each with half the number of chromosomes These two daughter cells undergo *mitosis* (*second meiotic division*) resulting in the formation of four daughter cells with half the number of chromosomes. During reproduction, these two daughter cells (one from the male and the other from the female) fuse and again the original chromosome number is restored

In addition, another important event occurs during meiosis. During the first meiotic division, when the chromosomes are getting ready to be halved in number, they undergo certain changes The homologous chromosomes, from each of the parents, come close together to form pairs. In a pair of chromosomes, the chromatids of one exchange their segments with the chromatids of the other Such exchange of segments bring changes in the gene composition of the chromatids, makes the chromosome different from the parent chromosome This causes variations within a species Though the chromosome number remains constant, yet in each generation some changes take place.

Thus, the significance of meiosis can be summed up as follows.

1. Each cell gives rise to four daughter cells by two successive divisions.
2. The daughter cells so formed are the mature male (sperm) or female (ovum) gametes which contain only half of the number of chromosomes.
3. The chromosomes of the daughter cells are different qualitatively from those of the parents.
4. This chromosomal variation results in bringing about structural diversity among the individuals of the same species

TEST ITEMS

1 Draw a diagram of an animal cell. Label the different parts
2. What is the electron microscopic structure of the cell membrane ?
3 Which cell organelles are found only in the plant cell ?
4 Describe the ways in which meiosis differs from mitosis

UNIT—3

LIFE PROCESSES

CHAPTER 9

Nutrition

1. Food is essential for all living organisms.
2. Food must include all the chemical substances which are essential for the body.
3. Green plants can synthesise their own food but non-green plants and animals directly or indirectly depend upon plants for their food.
4. Digestion renders the food suitable for utilisation in the body.

ALL living organisms require a continuous supply of materials and energy to perform the different life processes. Several varieties of molecules are essential for the formation and maintenance of the body substances Different groups of living organisms show different types of nutrition

AUTOTROPHIC NUTRITION

Green plants synthesise all their food requirements from simple inorganic raw materials A foodstuff is defined as a substance from which an organism derives energy and material for growth and maintenance. The green plants and a few types of bacteria which are completely self-supporting and are called *autotrophic organisms* or *autotrophs*. This mode of nutrition in green plants is achieved mainly by the process of photosynthesis. Thus autotrophic organisms are able to grow and multiply in a purely inorganic medium They do not depend on any outside source for their requirements of sugars, fats, amino acids and other complex molecules. The food manufactured or stored is translocated to different parts. It is digested inside the cell and is comparable to the intracellular digestion of animals.

HETEROTROPHIC NUTRITION

All animals including man and non-green plants show heterotrophic mode of nutrion. *Heterotrophic organisms* or *heterotrophs* constitute a major category of living organisms They obtain all their energy requirements mainly from organic substances like carbohydrates and fats They derive their foodstuffs directly or indirectly from the plants. Since the green plants are the food makers, they are in fact the mainstay of the living world When plant tissues are consumed by animals and man, the constituents of plant cells supply the building blocks of the body cells and the energy needed for the life processes of the animals and men

The nutritional requirements of man are more complex than those of the other organisms. Compared with many other organisms the synthetic machinery of man is less versatile Man depends on plants for the primary food supply either directly by taking plant products or indirectly by eating other animals that eat the plants. Man requires in his diet carbohydrates, eight of the twenty amino acids from which he can synthesise the other twelve and probably eight or more vitamins The heterotrophic nutrition is of two types. *saprozoic or saprophytic and holozoic*

In the saprophytic nutrition, for example, in non-green plants, the organisms secrete a starch-digesting enzyme to digest the food and then absorb the nutrients In saprozoic organisms like the malarial parasite in man and *Monocystis* in earthworm the already digested food is absorbed by the process of diffusion. But nutrition in most of the free living animals is holozoic In this type of nutrition, food may be a small organism, a plant or an animal. You are already familiar that this kind of nutrition takes place from protozoa to man In all the holozoic organisms, whatever may be the food, it must be taken in (*ingestion*), it must be digested (*digestion*), simplified products must be absorbed (*absorption*) and the residual products must be removed (*egestion*). The details of each of these steps are given below

INGESTION

Ingestion is the process by which food is taken by the organisms We know that some organisms eat plants or plant products (*herbivorous*), some eat animals (*carnivorous*) and some eat both (*omnivorous*) In the simple organism like amoeba, food is taken in at any place on the cell surface and it moves directly into a special organelle called food vacuole. In multicellular organisms like *Hydra*, the food is ingested into the hypostome with the help of tentacles. The earthworm has a muscular pharynx to swallow its food Arthropods like cockroaches have special mouth parts adapted for catching and cutting the food The vertebrates like frog, birds and mammals have well developed devices to take in the food

DIGESTION

Digestion involves various physical and chemical processes by which insoluble food is rendered suitable for absorption. In the unicellular organisms like amoeba (Fig 9.1), the food

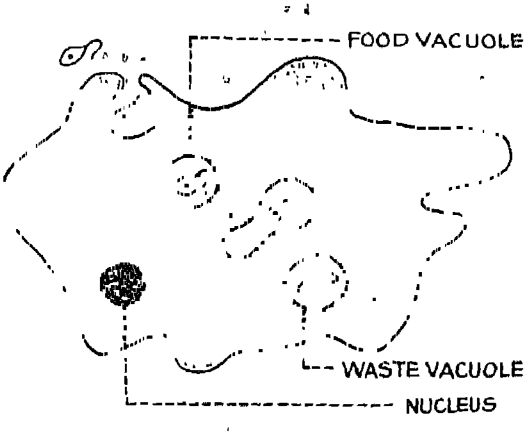


Fig 9.1. Intracellular digestion in amoeba.

in small food vacuoles is digested by the enzymes secreted by the cell cytoplasm. This is known as *intracellular* digestion. The higher organisms have special organs for the digestion of food. The food in these organisms passes through the alimentary canal. Here several digestive enzymes are secreted to break the complex food materials into simpler substances This process takes place outside the cell and is called *extracellular* digestion

Digestion of Food in Man. When we take food it is first mixed with saliva in the mouth and ground into a paste by the teeth Saliva contains an enzyme called salivary amylase (*ptyalin*) which converts starch into sugar. Then the food is swallowed and is moved down into the stomach through the oesophagus The presence of food in the stomach stimulates the tiny gastric glands to secrete enzymes, such as *pepsin*. Pepsin breaks down the proteins into simpler molecules known as peptides (small chains of amino acids). This process is aided by the secretion of dilute hydrochloric acid in the stomach. Sometimes, nervous tension and emotional upset result in the secretion of too much of acid causing hyperacidity. At this stage, the food takes turn into a soup. This soup enters the small intestine through the duodenum. Here the partly digested food is mixed with pancreatic juice secreted by the pancreas and bile secreted by the liver. The pancreatic juice contains enzymes like *trypsin*, *chymotrypsin*, *carboxypeptidase*, *amylase* and *lipase*. Trypsin and chymotrypsin act further upon some of the proteins and break them down into peptides and

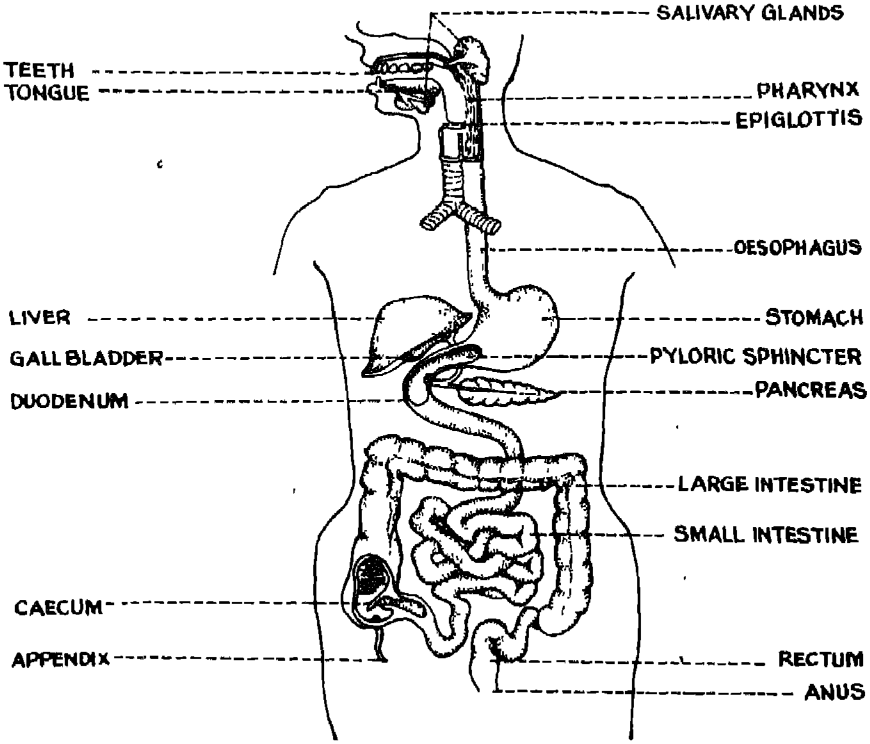


Fig 9 2 The digestive organs and alimentary system in man.

TABLE 9.1

DIGESTIVE ENZYMES: THEIR SOURCES AND EFFECTS

Part of the digestive system	*Source of enzymes*	*Name of the enzymes*	*Substances acted upon*	*Products*
Mouth	Salivary glands	Salivary Amylase (Ptyalin)	Starch	Complex Sugars
Stomach	Gastric glands	Pepsin	Proteins	Peptides and amino acids
Pancreas	Pancreatic juice	Trypsin, Chymotrypsin and Carboxypeptidase,	Proteins	Peptides
		Amylase,	Starch	Maltose
		Lipase	Fats	Fatty acids and Glycerol
Small intestine	Intestinal glands	Aminopeptidases,	Peptides	Amino acids
		Disaccharidases (Maltase, Lactase, Sucrase)	Maltose Lactose Sucrose	Glucose and other Sugars

amino acids Amylase turns the remaining starch into sugar and lipase acts upon the fats and converts them into soluble fatty acids and glycerol The digestion which started in the mouth is completed in the small intestine. All these end products are suitable for absorption into the blood stream. The intestinal glands secrete enzymes like *aminopeptidase* and *disaccharidases* (*maltase*, *lactase*, and *sucrase*) The former completes the hydrolysis of peptides into amino acids and the latter covert the disaccharides into monosaccharides. The digestive organs and alimentary system in man is shown in Fig 9.2 Table 9 1 shows the different enzymes, their sources and their effects on the food. It is to be remembered that in all organisms, these enzymes are practically of the same nature

ABSORPTION

In amoeba, the digested food is absorbed into the cytoplasm through the wall of the food vacuole.

The simplified products of digestion in higher organisms are absorbed in the small intestine through the intestinal wall which has numerous finger-like projections called villi

EGESTION

Although many enzymes act upon the food material, some part of the food is left undigested In unicellular organisms, these residual materials remain within the food vacuole and are finally discarded In *Hydra*, such residual matters are discarded through the mouth In higher organisms, this residual undigested food is passed on to the large intestine, where the water in it is reabsorbed and the semiliquid material is converted into the semisolid faeces. The faeces is expelled through the anus periodically.

TEST ITEMS

1. What are the important chemical components of food?
2 Give five examples of each of the following:
(i) Autotrophs; (ii) Saprozoa, (iii) Parasites (iv) Herbivores; (v) Carnivores and (vi) Omnivores
3. What are the important steps of holozoic nutrition?
4. Name the enzymes, in serial order of their action, which affect the following components of food: (i) carbohydrates; (ii) protein and (iii) fat
5. Indicate the changes in the food that take place in the small intestine

CHAPTER **10**

Photosynthesis

1. Photosynthesis is a unique energy trapping process and it converts solar energy into potential chemical energy.
2. Green leaves and other green parts of the plant are the sites of photosynthesis.
3. Photosynthesis is an intracellular process and is confined to the organelle called the chloroplast.
4. Carbon dioxide and water are the two raw materials for photosynthesis.
5. The chemical reactions in photosynthesis can be grouped into two categories:
   - (i) Light reaction or light dependent or primary process of photosynthesis in which water is split and assimilatory power is generated, and
   - (ii) Light independent or non-light requiring or dark reaction or secondary process of photosynthesis.

PHOTOSYNTHESIS is a unique process in the green plants which utilises solar energy and converts it into potential chemical energy. There are some bacteria beside the green plants which carry out photosynthesis Virtually all life on this planet depend on the products of the reactions of photosynthesis It is the only biological process that converts large quantities of radiant energy of sunlight into potential chemical energy. By means of this solar energy, the carbon dioxide from the atmosphere and hydrogen from water is incorporated into organic compounds at ordinary temperature Photosynthesis serves as a bridge to utilise this free energy from the sun to the living organisms. The conversion of one substance carbon dioxide into the body constituent of another substance (sugar) is known as carbon assimilation or photosynthetic carbon assimilation.

EXPERIMENT TO DEMONSTRATE EVOLUTION OF OXYGEN DURING PHOTOSYNTHESIS

1 Fix a rubber tubing to the tip of a 10 ml graduated pipette Tightly close the rubber tubing with the help of a screw clamp Fix the set-up to a burette stand (Fig. 10.1).

2 Collect a few *Hydrilla* twigs in a 500 ml beaker, after cutting them under water The plants should be cut carefully without pressing

3 Fix the cut ends of the *Hydrilla* plants into the pointed end of the pipette

4 Insert the pipette now in a beaker containing water Fill the pipette completely with water Leave the set-up in sunlight You will find the evolution of bubbles which displace the water in the pipette You can test the nature of the gas by introducing a burning splinter and show that it is oxygen.

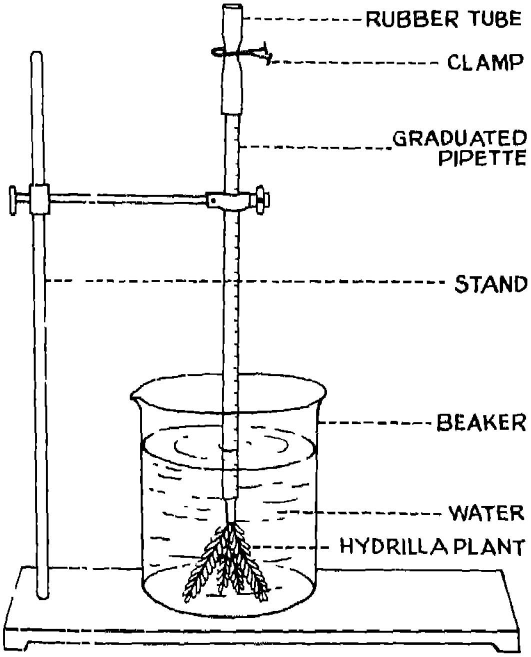


Fig. 10 1 The experimental set-up to demonstrate evolution of oxygen during photosynthesis

The radiant energy absorbed by the green leaves is used in transforming carbon dioxide and water into carbohydrates. Oxygen is liberated during the process Carbohydrates contain, in addition to carbon, the elements hydrogen and oxygen in the same ratio as in water

$$CO_2 + 2H_2O \longrightarrow (CH_2O) + H_2O + O_2$$

The parenthesis around CH_2O means that no specific molecule is indicated; but merely the ratio of atoms in the carbohydrate is indicated The energy stored in the foods in the form of chemical energy is continuously released in living cells during the process of respiration In the carbohydrate the carbon atoms are derived from CO_2

$$6CO_2 + 6H_2O \text{ —— } C_6H_{12}O_6 + 6O_2$$

The summary reaction of photosynthesis does not indicate the step-by-step sequence of the multi-step process leading to the synthesis of carbohydrate molecule and release of oxygen The various reactions in the process are catalysed by many enzymes, each one specific for a particular reaction. The above equation does not indicate whether the oxygen evolved comes from water or from carbon dioxide. However, experiments using water containing heavy oxygen (i e. oxygen with an atomic weight of 18) enabled one to follow the various chemical reactions and clearly demonstrated that oxygen liberated during photosynthesis comes entirely from water This also indicates that the process of photosynthesis in higher plants involves the splitting of the water molecules and liberation of oxygen from them. This event is called the photolysis of water. A more complete and revised equation of photosynthesis is indicated in the following overall equation.

$$6CO_2 + 12H_2O \xrightarrow[\text{chloroplast}]{\text{light}} C_6H_{12}O_6 + 6CO_2 + 6HO_2 + 114 \text{ kcal}$$

PHOTOSYNTHETIC RAW MATERIALS

Carbon dioxide and water are the two basic raw materials for photosynthesis. Both carbon dioxide and water have low potential chemical energy while the product of photosynthesis is of high potential chemical energy Carbon dioxide is obtained from the atmosphere The atmosphere normally contains about 3 parts/10,000 parts by volume of carbon dioxide.

Carbon dioxide enters the leaf through tiny pores on the leaf surface called the stomata Sometimes the carbon dioxide evolved during respiration in the plant is also utilised for photosynthesis Water, the other raw material for photosynthesis, is absorbed by roots of the land plants from soil and is conducted through roots and stems into the leaves.

CHLOROPLASTS : THE SITE OF PHOTOSYNTHESIS

All the green parts of the plant carry out photosynthesis and the leaves of all plants are ideally developed for this purpose. The process of photosynthesis takes place entirely within the subcellular organelles called the chloroplasts Chloroplasts of higher plants are lens-shaped or ellipsoidal and are found only in the green cells of plants They are collectively known as plastids. By examining a leaf section you can observe that the green pigment is limited to certain plastids known as chloroplasts The chloroplasts are most abundant in the elongated cells of the palisade tissue in the leaf But they also occur in the cells of the spongy mesophyll. The chloroplasts contain the green colouring pigment called chlorophyll.

LIGHT AND CHLOROPHYLL

EXPERIMENT TO DEMONSTRATE THE NECESSITY OF CHLOROPHYLL FOR PHOTOSYNTHESIS

1. Cut a variegated leaf of *Coleus* or *Manihot* or *Croton* or any other variegated leaf from a plant that has been exposed for several hours to bright light
2. Soak the leaf thoroughly in tap water, and place it on a dark background under a flat piece of glass Lay a transparent paper on the glass, and trace the outline of the leaf and the boundary between the green and the non-green portions.
3. Kill the leaf by dipping it in a beaker of boiling water.
4. Dip the dead leaf in a beaker containing 70 per cent alcohol and allow it to stand until the colour is completely extracted The colour can be rapidly extracted by placing the beaker on a hot plate
5. Carefully take the leaf into a petridish Immerse the leaf in a solution of iodine in potassium iodide.
6. Wash away the iodine with water Compare the area stained blue-black with the area you have drawn as originally green. Notice that starch is formed only where chlorophyll is present (Fig 10 2)

Visible white light as it comes to us from the sun is composed of light bands of different wave lengths The band of colours in the visible spectrum consists of relatively long waves of red light through successively shorter waves ending into violet light Human eye perceives the visible light of different wavelengths in the form of light of different colours In photosynthesis the light in the region of blue and red wavelengths of white light is most strongly absorbed and utilised More of the green light is reflected out and it is for this fact that chlorophyll is green to the eye The unit of light absorbed in photosynthesis is referred to as a photon or quantum.

The chlorphylls are contained in the chloroplasts The electron microscope has revealed that there are highly organised fine structures inside the chloroplasts The photosynthetic pigment, i e. the chlorophyll, absorbs light and mediates its conversion into chemical energy.

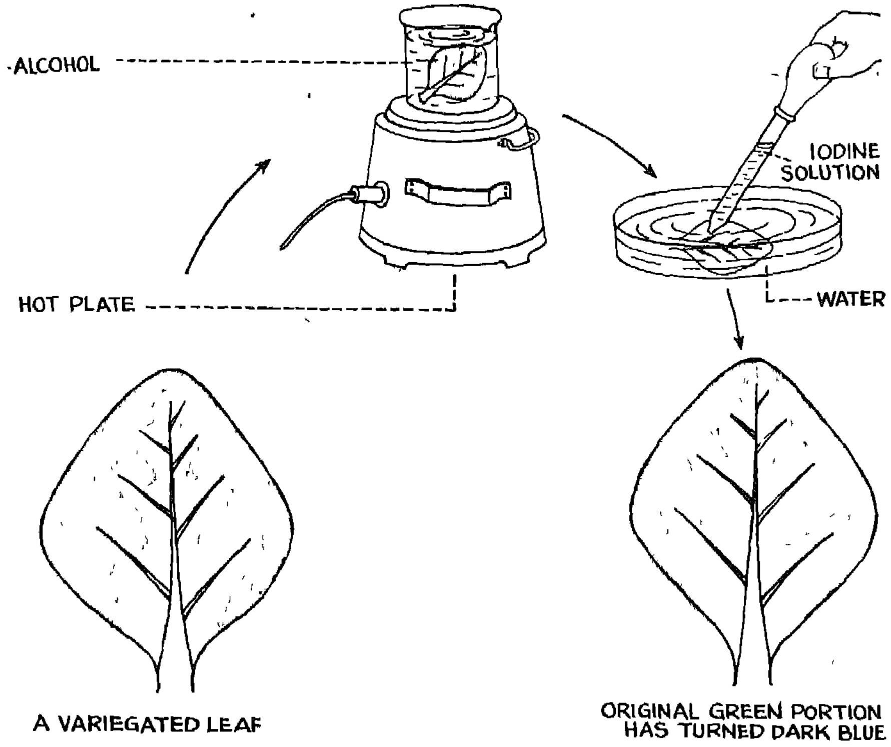


Fig 10 2 The experimental set-up to demonstrate the necessity of chlorophyll for photosynthesis

The chlorophyll plays a purely catalytic role in photosynthesis. It contains a mixture of four pigments—chlorophyll-*a*, chlorophyll-*b*, carotene and xanthophyll (lutein). It is a complex organic molecule and contains magnesium at the centre. You have already learned that chlorophyll is a green pigment and it does not absorb green light. Other pigments like carotene and xanthophylls are also associated with the chlorophyll in the green plant cells. Their presence in green leaves is usually masked by the greater abundance of the chloroplast.

PHOTOSYNTHETIC PROCESS

The process of photosynthesis can be divided into two sets of separate but interconnected reaction sequences

The first chain of events is called the *light reaction* or primary process of photosynthesis This is followed by the second sequence called the *dark reaction* or the secondary process of photosynthesis.

LIGHT REACTION OR PRIMARY PROCESS OF PHOTOSYNTHESIS

The essence of photosynthetic process lies in the use of light energy for splitting water into H^+ and OH^- ions. This process is called photolysis of water. The electrons released during these reactions eventually reduce the chemical

NADP (nicotinamide adenine dinucleotide phosphate) to $NADPH_2$ (reduced NADP). NADP is a coenzyme (a coenzyme is a non proteinaceous component of the enzyme which is essential for its activity) capable of readily accepting or donating hydrogen. The remaining OH^- ions from water are used to generate oxygen

The energy liberated in the above reactions of electron transfer is used in the synthesis of ATP (adenosine triphosphate) from ADP (adenosine diphosphate) and P_i (inorganic phosphate) during the transfer of electrons This is known as photosynthetic phosphorylation or photophosphorylation.

Thus the light reaction of photosynthesis results in the production of:

1. Reduced coenzyme. $NADPH_2$,
2. The energy rich compound ATP and
3. Liberated oxygen.

DARK REACTION (INDEPENDENT OF LIGHT) OR SECONDARY PROCESS OF PHOTOSYNTHESIS

ATP and $NADPH_2$ are the substances that link the primary process with the secondary process They are produced in the primary process and are used to drive the dark reactions of fixation and reduction of carbon dioxide ATP and $NADPH_2$, or together are described as the assimilatory power. The dark reaction or carbon reduction cycle is a complex metabolic cycle and is popularly known as the Calvin Cycle. These reactions involve the uptake of carbon dioxide by the plant and its reduction to CH_2O by hydrogen atoms set free by photolysis of water This reaction utilises the high energy of ATP and the reduced coenzyme, i.e $NADPH_2$

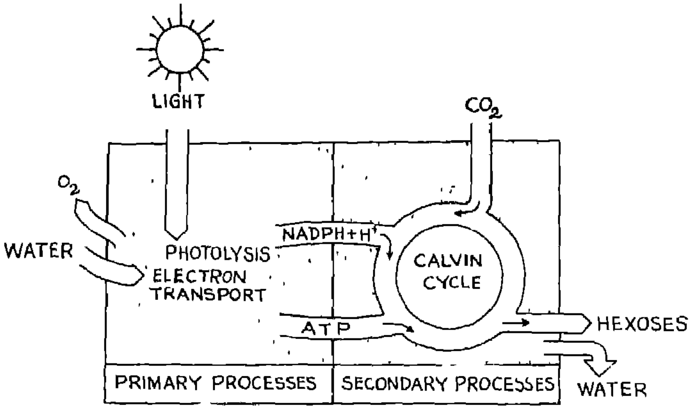


Fig 10 3. Schematic representation of the primary and secondary processes of photosynthesis.

THE CARBON DIOXIDE ACCEPTOR

To which substance is carbon dioxide bound? Or which substance is the carbon dioxide acceptor? Carbon dioxide is built up into a sugar phosphate called ribulose diphosphate (RUDP). The product of this reaction is phosphoglyceric acid (PGA). PGA is the first stable product formed in photosynthesis. RUDP is regenerated in the cycle of reactions. Thus carbon dioxide is built up into the organic molecules through a series or cyclic reactions and sugar (glucose) is ultimately synthesised.

In the field of photosynthesis the names of

Van Niel, Calvin, Arnon, Rabinowich and Govindjee stand out most prominently. It was due to the work of Van Niel and later Arnon and his associates that the events in the photochemical process in light reaction were discovered in the year 1954. Calvin and his associates elucidated the path of carbon in photosynthesis in dark reaction Calvin received the Nobel Prize in 1961 for his work on photosynthesis

The process of photosynthesis is of vital importance in that it replenishes the oxygen in the atmosphere, which is consumed in animal and plant respiration. Man not only lives on the products of current photosynthesis but utilises the fossil remains of the products of photosynthesis in the geological past, like coal, peat, oil and natural gas

TEST ITEMS

1 What is the site of photosynthetic reactions?
2. What are the two sets of reactions involved in photosynthesis?
3. What is the relation between chloroplast pigments and light? What is a coenzyme?
4 What is the source of oxygen released during photosynthesis?
5. Describe an experiment to prove the necessity of chlorophyll for photosynthetic activity.

CHAPTER **11**

Respiration

1. Respiration is an intracellular process.
2. The process of respiration is common in all plants and animals.
3. In the process of respiration, the oxidation of foodstuffs is coupled with the formation of ATP, the energy currency of the cell Respiration involves generation of energy in the form of ATP.
4 The process of respiration involves many steps which are controlled by various enzymes.
5 Mitochondria, the subcellular organelles, are the site for respiratory activity.

THE various life processes taking place in plants and animals require available free energy The energy released from the spontaneous breakdown of foodstuffs during respiration is used for the vital activities which are characteristics of life. Fig 11 1 summarises the need for energy in living cells

Respiration is a fundamental process of energy release and it occurs in all living cells During respiration, energy-rich foodstuffs are oxidised to simpler substances like water and carbon dioxide coupled with the release of usable energy within all living cells. Respiration involves an exchange of gases, i.e. an uptake of oxygen and release of carbon dioxide Respiration is not to be confused with breathing During breathing organisms get oxygen from the environment into their bodies so that it can be carried through specialised organs of breathing Release of energy occurs only via chemical reactions Biologists usually term this energy releasing process as biological oxidation or cellular respiration All the reactions of biological oxidation are catalysed by several specific enzymes The principles of biological oxidation are essentially the same for all organisms from bacteria to man. This is one of the best examples of functional unity in spite of structural diversity in living organisms. Biological oxidation also serves to supply a pool of intermediate organic compounds that can be used for the synthesis of other essential compounds.

In chemical terminology a substance is oxidised when it loses electrons and reduced

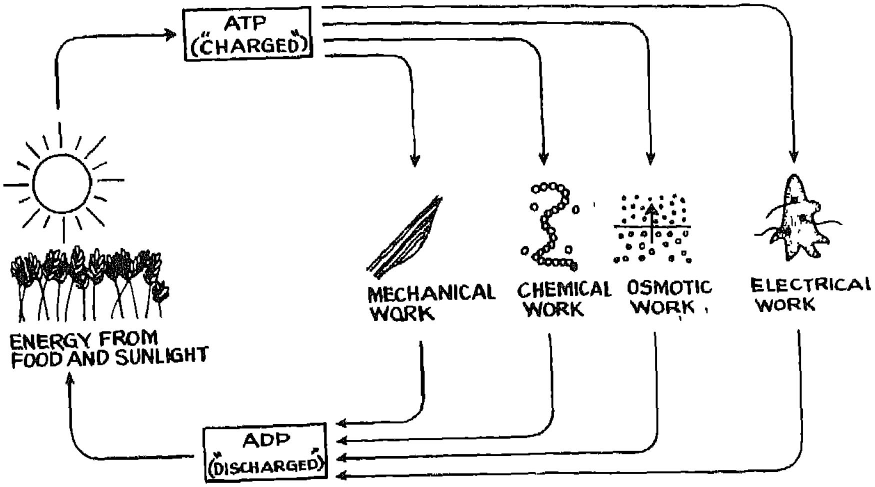


Fig. 11 1. ATP formation during photosynthesis and respiration and the use of this ATP in various cellular activities converting ATP into ADP

when it gains electrons. Now the term oxidation does not necessarily mean that it is limited to the combination of a substance with oxygen If one substance becomes oxidised, there must be a simultaneous reduction, for the electrons lost by one substance are gained by another The exchange of electrons is accompanied by the release or absorption of energy.

Cellular respiration is different from the burning of a flame or a match stick where oxygen of the air combines with the oil or wood and energy is released at once and is lost in the form of light and heat and the fuel is broken down into carbon dioxide and water. On the contrary, in cellular respiration, energy release is controlled and conserved in specific compounds capable of storing and releasing the energy when needed. Cellular respiration goes on at ordinary temperature. Even in biological oxidation some energy is lost as heat from the

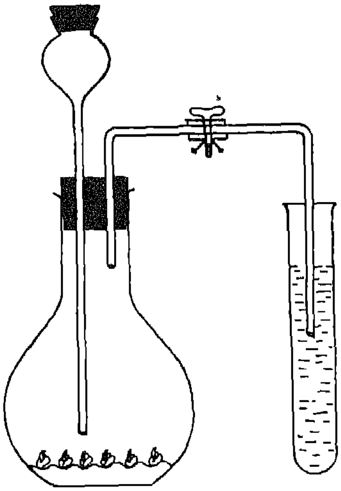


Fig 11.2 The experimental set-up to demonstrate production of carbon dioxide during respiration.

cell A key substance, common to all organisms, which is the storehouse for this chemical energy is known as adenosine triphosphate or ATP ATP serves as the universal intracellular carrier of chemical energy and it meets usually all the energy demands of the cell.

Glucose, a hexose sugar, is the usual organic substance which is utilised in biological oxidation. However, other substances like fat, organic acids and even protein are also consumed in respiration The energy stored in glucose, as you have learned, is derived from sunlight.

EXPERIMENT TO DEMONSTRATE PRODUCTION OF CARBON DIOXIDE IN RESPIRATION

1. Keep some germinating seeds in a flask and plug it with a two-holed rubber cork.
2. In one of the holes introduce a water reservoir with a provision for stop-cock.
3. Take a twice bent glass tube and connect the flask with a test tube containing water through the second hole of the rubber cork as shown in Fig. 11 2.

Leave the set up for an hour or two Then replace the water at the open end with lime water Leave the stop-cock of the reservoir such that water nearly fills the flask and the air of the flask is sent through the lime water The lime water is turned milky which shows that germinating seeds give off carbon dioxide during respiration

THE OVERALL PROCESS OF RESPIRATION

As indicated earlier, respiration is a cellular process and it is also a complex chemical process. It consists of numerous sequential chemical reactions and all of them are enzymatically

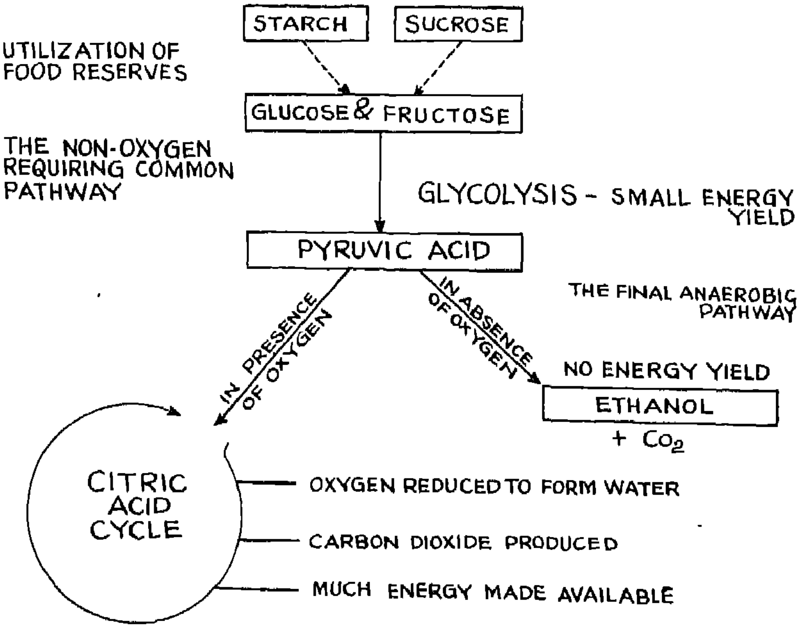

STARCH
SUCROSE
UTILIZATION OF FOOD RESERVES
GLUCOSE & FRUCTOSE
THE NON-OXYGEN REQUIRING COMMON PATHWAY
GLYCOLYSIS - SMALL ENERGY YIELD
PYRUVIC ACID
IN PRESENCE OF OXYGEN
IN ABSENCE OF OXYGEN
THE FINAL ANAEROBIC PATHWAY
NO ENERGY YIELD
ETHANOL
+ Co2
CITRIC ACID CYCLE
OXYGEN REDUCED TO FORM WATER
CARBON DIOXIDE PRODUCED
MUCH ENERGY MADE AVAILABLE

Fig 11.3. The sequence of events in respiration.

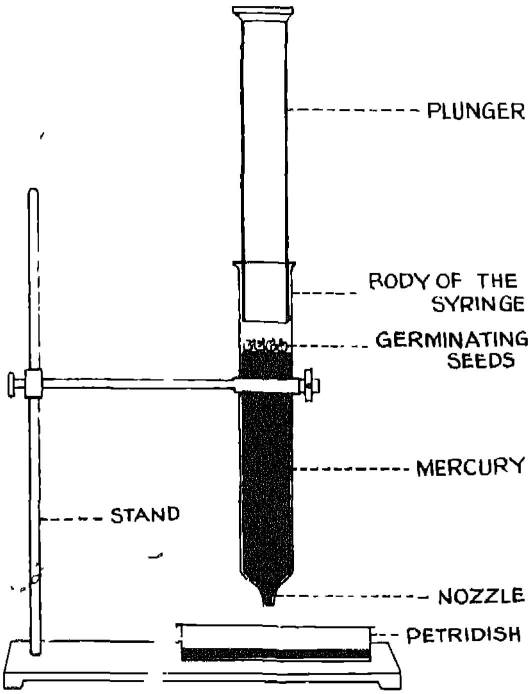


Fig. 11.4 The experimental set-up to demonstrate anaerobic respiration

controlled. The overall process of respiration is summarised in the following equation.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{cytoplasm, mitochondria}]{} 6CO_2 + 6H_2O + 686\ \text{kcal}^*$$

This equation represents the oxidation of hexose sugar, namely glucose, in the presence of oxygen from the air. The above equation merely indicates the two reacting substances, sugar and oxygen, and the two end products, carbon dioxide and water. But this does not indicate the complete reaction sequence or the pool of intermediate substances of the process. This breakdown of sugar into carbon dioxide and water requires more oxygen than is contained in the glucose molecule. So oxygen has to be supplied from the atmosphere.

During the process of respiration, glucose first undergoes a series of changes. The atmospheric oxygen does not enter into these initial reactions in which some intermediate compounds are formed and small amounts of energy are released. This series of early reactions is known as glycolysis (Fig. 11.3), which consists of the following three steps. In these steps a series of reactions takes place, each catalysed by a particular enzyme. Glycolytic reactions take place outside the mitochondria in the cytoplasm.

PHOSPHORYLATION

You have studied that phosphorus compounds serve as intermediate steps in photosynthesis and glucose phosphate is formed. Similarly in respiration the glucose molecule is activated by its attachment with phosphate to form glucose phosphate.

SUGAR CLEAVAGE

Later the 6-carbon molecule of glucose phosphate is split into two 3-carbon molecules which are still combined with phosphorus. You will recall that during photosynthesis also a 3-carbon compound, containing phosphorus, is formed.

PYRUVIC ACID FORMATION

In a series of reactions the sugar fragments containing phosphorus lose their phosphorus and some of their hydrogen atoms resulting in the formation of the 3-carbon intermediate compound called pyruvic acid So far the oxidation of the sugar has occurred through a rearrangement of the atoms within the molecule and removal of some of its hydrogen. NAD (nicotinamide adenine dinucleotide), a coenzyme molecule, serves as the universal hydrogen carrier in respiratory reactions. In this way $NADH_2$ is formed by some oxidation reactions in respiration. In the later steps of respiration $NADH_2$ is oxidised and the energy it contains is used in the formation of ATP from ADP and inorganic phosphate

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* The complete oxidation of 180 g of glucose yields 686,000 calories of energy in the form of heat. Much of this energy is utilised in carrying out cellular activities. One gram mole of a substance is its molecular weight expressed in grams, e.g. one gram mole of glucose weighs 180 g.

The units of energy are frequently expressed as kilocalories (kcal) or as calories per mole of the substance.

The amount of the heat energy required to raise the temperature of one gram of water (at 15°C) by one degree Celsius is known as a calorie (1 cal=4.18 Joules).

The fate of pyruvic acid now depends upon the availability of oxygen It may be noted that pyruvic acid is the key intermediate compound to both aerobic and anaerobic respiration.

EXPERIMENT TO DEMONSTRATE ANAEROBIC RESPIRATION

1 Remove the plunger from a syringe. Keep some germinating seeds of peas or bengal gram in the syringe and introduce the plunger (Fig. 11.4)
2. Keep the nozzle of the syringe in mercury and carefully draw 3-4 ml of mercury into it
3. Remove the syringe from mercury and by keeping the nozzle upwards expel the air from the syringe Loss of drops of mercury may be avoided by keeping a petridish below the syringe.
4 Keeping the thumb under the nozzle, bring the nozzle downward and keep a petridish underneath.

Leave the set-up for some time The gas liberated from the seeds pushes up the plunger or pushes some mercury through the nozzle. The nature of the gas liberated can be tested by introducing lime water or a burning splinter.

Anaerobic Respiration. The further conversion of pyruvic acid depends upon the presence or absence of oxygen. When respiration is carried on without oxygen pyruvic acid is incompletely reduced to ethyl alcohol and carbon dioxide in the final stage These reactions are confined to the soluble portion of the cell cytoplasm

$$C_6H_{12}O_6 \longrightarrow C_2H_5OH + 2CO_2 + 54 \text{ kcal}$$

The term glycolysis is usually applied to anaerobic breakdown of sugar Thus, glycolysis involves a series of reactions starting from carbohydrate to lactic acid by way of pyruvic acid in the absence of oxygen. The term 'anaerobic respiration' is limited to higher organisms and 'fermentation' refers to the breakdown of sugar by yeasts and bacteria. There are species among both plants and animals which can tolerate complete absence of oxygen.

Yeast produces alcohol during fermentation, but if oxygen is available it is utilised to carry on cellular respiration. Fermentation by yeast is also characterised by the production of a variety of end products. Yeast is extensively used for fermenting fruit juices in the production of alcoholic beverages.

In the human body, during muscular exercise energy demand is in excess than that is supplied by respiration. There is insufficient supply of oxygen from lungs through blood vessels and through cell membrane into cells. Muscle cells carry on anaerobic respiration temporarily. Under these conditions lactic acid is accumulated, which is slowly removed in the blood stream or reoxidised during the resting period In man and most animals the cells can carry on anaerobic respiration for some time, but ultimately they must have oxygen to continue the more efficient aerobic process

Aerobic Respiration: In the presence of oxygen pyruvic acid becomes further oxidised by dehydrogenation, to carbon dioxide and water through the reactions of oxidative cycle, water is formed due to the combination of oxygen with the hydrogen The cells usually obtain their energy requirements in bulk through aerobic respiration These reactions occur within small structures that are present in the cytoplasm known as mitochondria. Mitochondria are barely recognisable as oblong or rod-like structures when viewed under a light microscope These structures are generally considered as the power plants of the cell. A series of cyclic reactions take place in the mitochondria and is known as Krebs cycle (or TCA cycle) The greatest energy turnover occurs during the terminal stages of oxidation of pyruvic acid to carbon dioxide and water. Thus the overall process involving the complete oxidation of glucose to carbon dioxide and water is called respiration (glycolysis plus Krebs cycle) From the foregoing account it is clear that glycolysis, fermentation and respiration share a similar sequence of reactions upto the formation of pyruvic acid These series of reactions converting pyruvic acid to carbon dioxide and water can be divided into three steps

Formation of Active Acetate. Before the pyruvic acid enters the Kerbs cycle of reactions, it is prepared for the cycle of reactions by its conversion into activated acetic acid known as Acetyl Coenzyme A(Acetyl-CoA)

The oxidative cycle of respiration: This series of reactions is known as the Krebs cycle after Sir Hans Krebs, a physiologist whose research contributed a great deal to our knowledge of respiration. Krebs received the 1953 Nobel Prize for medicine.

Krebs cycle involves the gradual breakdown of pyruvic acid Other organic acids in the cell combine with pyruvic acid derivative. Carbon dioxide is released and hydrogen atoms are removed in several stages The sequence of reactions are cyclic rather than linear which means that the system is self-generating This cycle of reactions occupies a key position not only in cellular respiration but in cellular metabolism also

Terminal oxidation. This is the final stage of aerobic respiration The Krebs cycle, rather like a conveyer belt, hands over the hydrogen to the electron transport chain. The hydrogen that has been removed previously from the substrates being respired is picked up by a series of enzymatic reactions. This hydrogen combines finally with oxygen of the air and water is formed As the electrons flow down the chain energy is conserved by the formation of ATP. Most oxidations in a cell end with the reduction of molecular oxygen to water.

In the field of respiration studies, the names of Warburg, Keilin and Krebs stand out most prominently and their work greatly contributed to the understanding of the biochemistry of respiration

The importance of cellular respiration lies in the production of ATP from glucose The controlled step-by-step oxidation of glucose in cellular respiration permits a bulk of energy conserved as chemical energy in the form of ATP

One of the fundamental principles in fruit and vegetable storage is to reduce the rate of cellular respiration, which tends to prolong the storage life, i.e the transition from mature green to ripe stage Generally lower temperatures reduce the respiration while higher temperatures hasten ripening.

TEST ITEMS

1. How does respiration differ from breathing? What is the difference between respiration and combustion ?
2. What are the major steps in respiration ?
3. What is the pivotal or important intermediate compound produced in respiration ?
4. What are the end products formed in aerobic and anaerobic respirations ?
5. Name the principal coenzyme concerned in the oxidation-reduction reactions in respiration.

CHAPTER **12**

Internal Transport

1. There exists a mechanism of transport inside the body of a multicellular organism
2. In animals and plants, the cell-to-cell movement of substances takes place through diffusion.
3. In higher animals, the circulatory system transports both gases and different substances.
4. In the vertebrates there are two kinds of circulating fluids, blood and lymph. Blood flows through a closed network of vessels and lymph bathes the cells.
5. The blood in vertebrates consists of plasma and blood corpuscles There are several types of blood cells. The red blood cells carry oxygen.
6. In plants, the internal transport involves the ascent of water and minerals and both downward and upward translocation of food manufactured in the leaves Xylem and phloem are the conducting tissues in plants.

THE complex structural organisation of multicellular ornanisms requires a mechanism to transport materials throughout the body In simple multicellular organisms like hydra and in unicellular organisms like amoeba, paramoecium, chlamydomonas and other algae this is achieved by diffusion. The transport in more complex animals is carried out through the circulatory system In higher plants, the transport within the body is carried out through the conducting tissues like xylem and phloem and through the intercellular spaces.

TRANSPORT IN UNICELLULAR ORGANISMS

You are already familiar with the unicellular organisms like amoeba, paramoecium and algae. The gases, minerals and organic substances which are dissolved in water get into the cells of these organisms mainly by an active process which requires energy and also partly by diffusion In the same way, the waste materials from these organisms are removed from their body.

INTERNAL TRANSPORT SYSTEM IN MAN

In all vertebrates a liquid tissue is always kept circulating throughout the body This liquid tissue is called blood. It is circulated through narrow, elastic, closed tubes—the blood vessels. Blood is kept continuously moving in the blood vessels by the pumping action of the heart

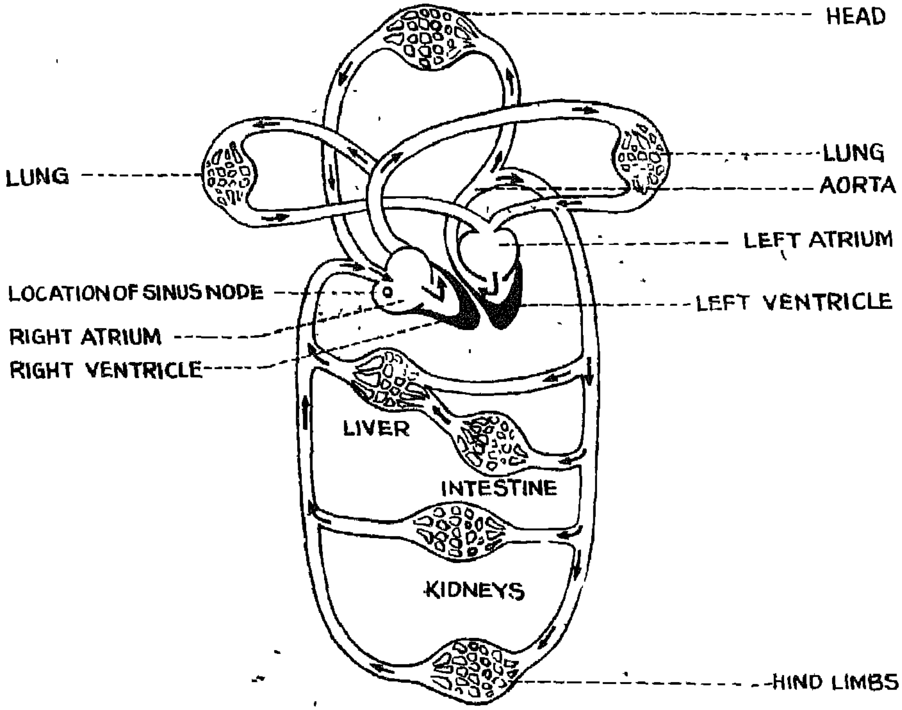


Fig 12 1. A schematic representation of the circulatory system in man

The schematic structure of the circulatory system in man is shown in Fig. 12.1. The heart, in fact, has two water-tight chambers, the receiving chamber called auricle and the distributing chamber called ventricle. The left half of the auricle receives purified blood from the lungs and empties into the left ventricle. The left ventricle distributes blood to various organs and tissues through the blood vessels These blood vessels which carry blood from the ventricle to the tissue are called arteries. These have thick elastic walls which can contract. On reaching the concerned organ each artery divides into arterioles of small dimensions These in turn divide inside the tissue into capillaries of finer dimensions It is here that the blood gives off its food and oxygen and collects carbon dioxide and waste materials. This is possible because the walls of the capillaries are extremely thin. The blood that has become impure through the collection of waste materials is now cleared from the tissues by a set of blood vessels called veins. Several veins from different organs join to form venous trunks or venae cavae. The two venae cavae empty the deoxygenated blood into the right auricle. From here, the blood is passed on to the right ventricle which pumps it to the lungs for oxygenation. The oxygenated blood returns to the left auricle. Thus the circuit is completed.

Thus, nowhere in the body the blood actually comes into direct contact with the tissues. It is always inside the blood vessels. Therefore, this type of circulation is called 'closed circulation'. When the blood flows from the arterial end or the capillaries to its venous end, due to pressure differences, fluid filters out of the thin-walled capillaries at the arterial end. This fluid is called the tissue fluid. It carries with it salts, sugars, amino acids and gases dissolved in it. The excess tissue fluid either gets back into the capillaries at their venous ends or gets back through another system of transport vessels, the lymphatic system. The excess tissue fluid collected by these lymph vessels is finally poured back into the blood as lymph into the large venous trunks. There it mixes with blood and loses its identity.

The heart goes on beating from long before the time of birth to death. It goes on contracting and relaxing alternately. It does so to pump blood through blood vessels and to keep it moving. The contraction is called systole and the relaxation diastole. The heart can beat on its own accord without any nerve supply. But the heart is supplied with nerves. These nerves serve to control the rate of heart beat. The beat can either be hastened or slowed down by these nerves. The normal rate of heart beat in man at rest is 65-75 per minute.

This fluid tissue, the blood, consists of various cells and cell-products floating in a watery substance known as the plasma. In a healthy person about 5.6 litre of blood is present. The plasma is composed principally of water with a large number of proteins, called plasma proteins. These plasma proteins help in retaining water, in clotting of blood at the site of injury, and in combating disease producing organisms. The plasma also contains sugars, salts, amino acids, oxygen and other substances useful to cells. The waste products of cells, such as urea, carbon dioxide and others are also present in plasma. The red blood cells (RBC) are the most numerous in blood. Each cubic millimetre of blood contains about 5 million RBCs. They are produced in bone marrow. By the time they reach the blood stream they lose their nuclei. Each is a tiny bag of haemoglobin which can carry oxygen or carbon dioxide. The white blood cells (WBC) are less numerous. About 5,000 to 7,000 are seen in one cubic millimetre of blood. They are formed in bone marrow, lymph nodes and spleen. The white blood cells are of different types. They protect the body against infection and disease. In addition to RBCs and WBCs, blood also contains small cell fragments called blood platelets. These blood platelets help in clotting of blood at the site of injury.

TRANSPORT OF MATERIALS IN PLANTS—TRANSLOCATION

Plants utilise simple inorganic substances like carbon dioxide, oxygen, water and mineral salts for all their synthetic activities. You have already learnt that carbon dioxide and oxygen are taken from the atmosphere by the leaves. Water and dissolved mineral salts are absorbed by the root system and are conducted to the leaf and stem tip where they are utilised. You have studied that water is utilised in the leaves where it participates in photosynthesis.

Sugars are manufactured in the leaf by the process of photosynthesis and are translocated from the leaves into the stem. Along the stem they are redistributed to sustain the growing points of root and shoot, to storage organs and during reproduction to the developing flower.

All this movement of substances from one region of synthesis or plentiful availability (source) to the region of utilisation (sink) is called translocation. This is essential for carrying out the various vital activities of the land plant. In a land plant, xylem and phloem tissues are concerned with the translocation of these substances.

PATH OF TRANSPORT

Translocation occurs in the tissues of xylem and phloem. The xylem consists of thick walled tubes of dead cells. Water is conducted through the xylem from the root to the leaves, where it is partly utilised and the bulk of it is evaporated from the leaf surfaces. Minerals dissolved in water are absorbed from the soil and are moved upwards to the leaves mainly by way of xylem. So xylem forms the 'pipeline' for conducting water. On the other hand, the synthesised foods are conducted from the leaves to the roots and to the shoot tips through phloem tissue which consists of living cells. These cells are joined end to end; their end walls are sieve-like and are perforated. These are called sieve tubes (Fig. 12.2). Sucrose is the main form in which carbohydrate is transported in the phloem. Both xylem vessels and sieve tubes form continuous ducts which extend almost from the root tip to the stem tip. The thin walled sieve tubes are supported by fibres in certain plants. In jute and hemp these fibres are extensively developed and the fibres are of economic importance.

DEMONSTRATION OF THE TRANSLOCATION OF FOOD MATERIALS

The movement of food substances in plants can be demonstrated experimentally by removing the bark, known as girdling. Girdling blocks the movement of food substances down the trunk. Sugar moves through the plant both upwards and downwards. In pumpkin (*Cucurbita moschata*) food substances move from the leaves at the rate of 160 cm of phloem in an hour.

DEMONSTRATION OF TRANSPORT OF WATER

The transport of water in the xylem can be easily examined by placing a cut shoot of a balsam (*Impatiens* species) plant, in dilute eosin or safranin dye. After a few hours, sections from the terminal region clearly indicate the presence of the dye in the xylem region. This can be

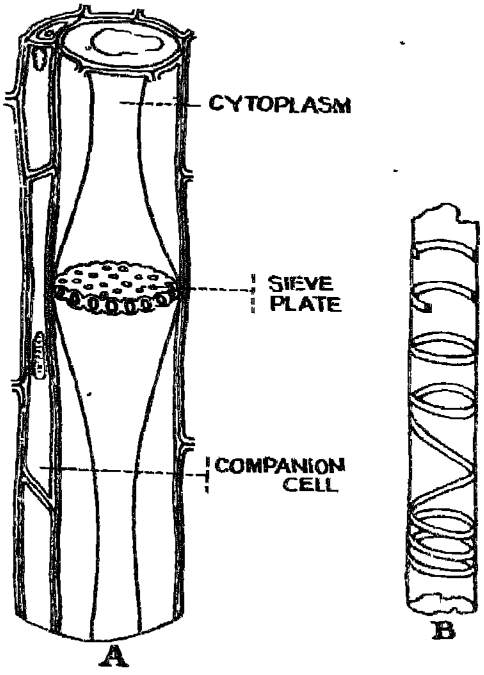
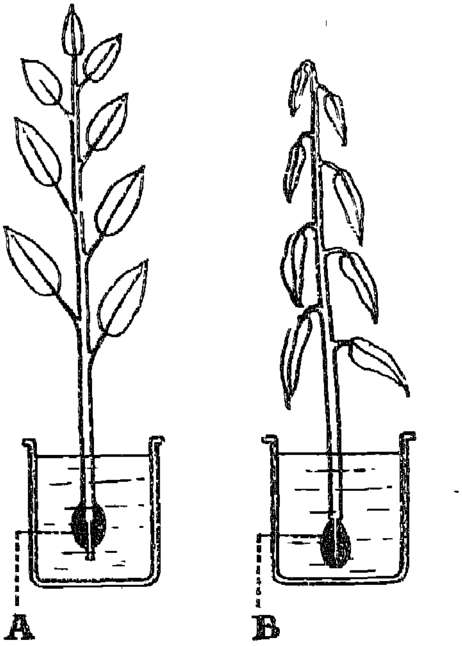


Fig. 12.2. A. Sieve plate connecting two sieve tubes. B. Xylem vessel of a flowering plant showing thickened wall.

demonstrated by another simple experiment. Cut two leafy shoots from a woody plant and carefully apply wax to cover xylem in one twig and phloem in the other as shown in Fig. 12.3. Leave the twigs in water. When the xylem is blocked, it prevents the conduction of water and the plant wilts. On the other hand when the phloem is blocked the plant remains unaffected.

There are several theories to explain the uptake of water. Sir Jagadish Chandra Bose suggested that water moves up by a pulsatory movement of the cells. Of course, his findings have not been confirmed by other scientists.

In agricultural practices, making use of the principle of translocation certain mineral deficiencies are made good by applying the nutrient solution through the leaves. Many of the pesticides, herbicides and growth regulators used extensively in agriculture depend on their effects on the principle of translocation.



ig 12.3. Experiment to demonstrate the transport of water by blocking phloem (A) and xylem (B).

TEST ITEMS

1. What are the different kinds of transport systems found in the living organisms?
2. Name the substances which are carried by the transport system in man.
3. What are the various components of blood?
4. Name the substances that are translocated through xylem and phloem?
5. Describe an experiment to demonstrate the ascent of sap in plants.

CHAPTER 13

Excretion

1. All living organisms, during their metabolic activities, accumulate waste products.
2. Each organism has a mechanism of its own to remove these waste products.
3. Plants also excrete excess and waste materials.
4. The most complicated and perfect mechanism of excretion is shown by the mammalian kidney.
5. There are other organs in man which act as excretory organs to remove the metabolic wastes.

You have already studied that plant and animal cells are engaged in various synthetic and oxidative reactions for the normal life processes of the organisms. In the course of these reactions, numerous waste products are formed which are unwanted and often toxic (Fig. 13 1). The natural mechanism does not allow these substances to accumulate and the organisms possess one mechanism or the other in order to eliminate them from the system. The process by which such waste products are removed from the body of an organism is called excretion.

You have learnt that carbon dioxide and water are the byproducts of respiration in plants as well as in animals. These are excreted by a simple process of diffusion from the surface of the body in lower plants and animals, through the stomata in the leaves, through the gills in fish and lungs in man.

EXCRETION IN MAN

Apart from the carbon dioxide which is excreted through the lungs, almost all other waste products in the body fluid are removed by special organs known as kidneys (Fig. 13.2). You know that in human beings there are two kidneys attached to the dorsal side of the body wall, one on either side of the vertebral column. Each kidney is connected with the urinary bladder by a duct called ureter. It opens to the exterior through urethra. Each kidney is made up of about a million of long, coiled fine tubes called nephrons. A nephron opens into a duct

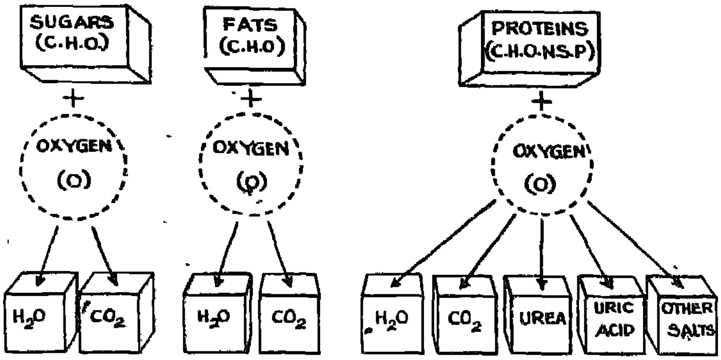


Fig 13 1 The waste products are formed when sugars, fats and proteins are oxidised.

that collects urine, while the other end is in the form of a hollow cup known as Bowman's capsule It surrounds a capillary tuft known as glomerulus. The glomerulus originates from the renal artery The removal of urea and other waste products in the blood takes place between the glomerulus and Bowman's capsule. The blood leaving the glomerulus, now free of its waste products, passes out of the kidney through the renal vein.

The incoming blood in the artery and its capillaries has a high concentration of urea. The tubule has a low concentration of urea The nephron filters the blood. How does the filtering take place? The blood in the glomerulus is under pressure which causes water and other soluble molecules present in the blood to filter through the capillary walls. The fluid produced is called the nephric filtrate. The nephric filtrate is simply blood plasma minus almost all the blood proteins The nephric filtrate collects within Bowman's capsule. From there it passes into the proximal part of the tubule (Fig. 13.3). It is in this part that the reabsorption of glucose, amino acids, vitamins, hormones

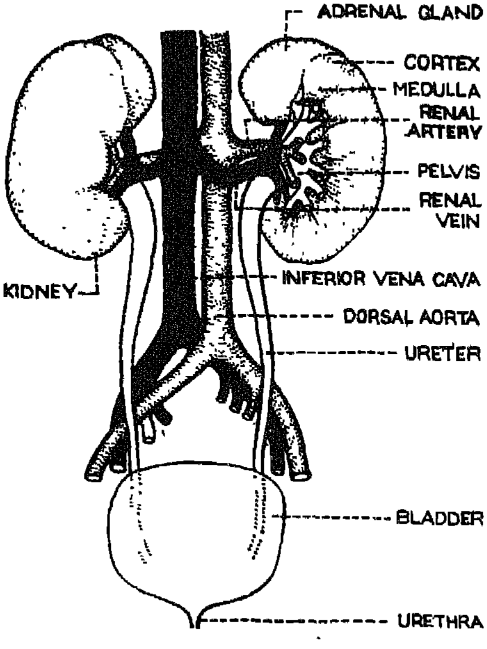


Fig 13 2 The kidneys and the associated structures in man The left kidney has been partially sectioned to show the internal structure

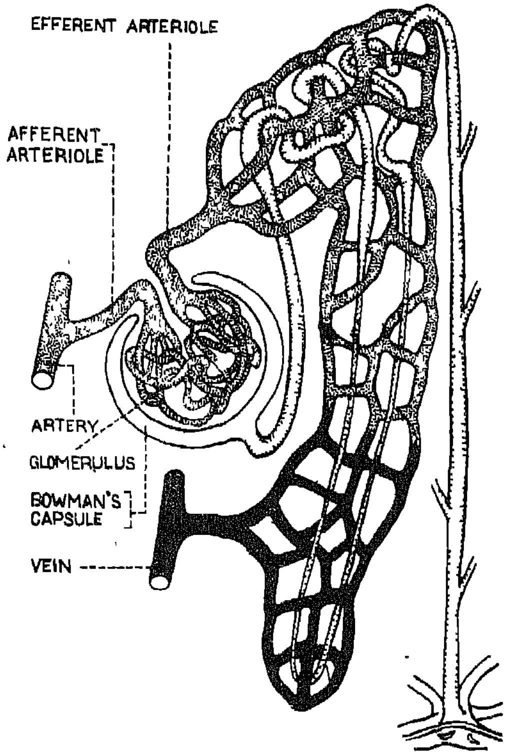


Fig 13.3 Detail structures of a nephron with its capillary network

and a large quantity of mineral salts take place. The reabsorption takes place by a process of active transport ATP generated in the mitochondria and certain specific enzymes are involved in the process of reabsorption The materials reabsorbed by the proximal tubules are returned to the blood stream which surrounds the tubules Along with the various components of the nephric filtrate that are reabsorbed and returned to blood, a large amount of water flows. This water is reabsorbed in the proximal tubule by the process of osmosis. The transfer of solutes from the nephric filtrate to the blood results in an increase in the proportion of water in the nephric filtrate. The water then passes into the blood by osmosis and restores the osmotic equilibrium

The quantity of nephric filtrate produced in the millions of nephrons is considerable. Nearly 80 per cent of water in the nephric filtrate is reabsorbed by the proximal tubule.

It is estimated that considerable amounts of sodium bicarbonate, sodium chloride, glucose and smaller amounts of other useful substances, along with water, are all reabsorbed in the tubule itself Now you can well appreciate that life cannot be sustained for long if this process of reabsorption fails and the materials simply pass out of the body. Thus an important function of the kidneys is balancing the amount of water in the blood with the amount of water in the cells. If this is not done osmosis may cause excessive amounts of water either to enter or to leave the cells causing disruption of the normal functioning of the body leading to death It is estimated that nearly 180 litres of fluid are filtered daily by the kidneys. But the urine formed is only 0.5 to 1 litre. The urine is collected by the collecting tubules and drained into the bladder through the ureters. The urine collected in the bladder contains the final waste products such as urea and some inorganic salts.

OTHER ORGANS OF EXCRETION IN MAN

Along with the kidneys, four other major organs are also involved in excretion. These are skin, lungs, intestine and liver.

Skin. The skin acts as an organ of excretion with the help of the sweat glands present in it. These glands remove water, urea and some salts from blood and excrete them on the surface of the skin. The excretion of water by sweat glands aids in regulating the body temperature whenever there is vigorous muscular exercise; or if the external temperature is high, the temperature of the blood tends to rise and consequently sweat is produced. Evaporation of sweat cools the skin and aids in maintaining a constant internal body temperature.

Lungs. The lungs are the chief organs of respiration. They absorb oxygen and eliminate carbon dioxide. The loss of water vapour during breathing is an unavoidable consequence The alveoli of lungs must remain moist if they are to remain in an active state. But the air that you breathe in is dry and this causes steady loss of moisture. The rate of respiration is regulated by the nerves. Human beings breathe normally about 15 times per minute.

Intestine. The intestine plays a minor role in excretion. It has a lining of epithelial cells. These cells excrete certain salts, for example, those of calcium and iron. These salts are eliminated along with the faeces. However, the undigested food material in the intestine does not enter into the blood or cells Therefore, it is eliminated from the body as faeces. This process is better called egestion rather than excretion.

Liver. The liver is an excretory organ. However, it plays only a minor role in excreting waste products directly from the body and hence it may also be considered as an accessory excretory organ. Urea, the chief nitrogenous waste material in the human body, is formed in the liver. The break-down of amino acids, which takes place in it, results in the accumulation of nitrogenous wastes. These nitrogenous wastes break down further into ammonia. Ammonia is a very toxic substance and its accumulation is therefore dangerous and even fatal. However, the liver converts the ammonia along with carbon dioxide into urea with the help of specific enzymes. Urea is removed by the kidneys eventually.

The haemoglobin of the dead red blood cells is broken down in the liver. In this process, the liver manufactures bile pigments. Through the bile ducts, the bile pigments pass into the intestine and are thrown out along with the faeces. In fact, the bile pigments are the true metabolic wastes in the faeces.

EXCRETION IN PLANTS

Plants absorb the required amounts of nutrients and water from soil and atmosphere. Therefore, compared to an animal, the elimination of wastes is much less in plants. The rate of catabolism in plants is usually much lower than in animals. Metabolism in the green plants is versatile in the sense that they are capable of utilising some of the waste products of catabolism in the anabolic process. Leaves, bark,

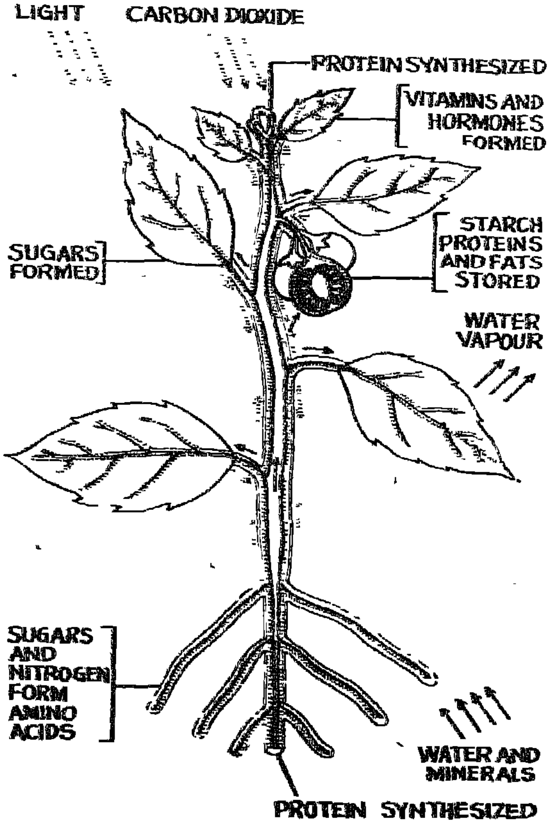


Fig. 13.4. Synthetic activities of a plant.

roots and seeds usually are concerned in the process of eliminating or storing excess or waste materials.

Water and carbon dioxide which are the end products of respiration are mostly utilised in photosynthesis. Likewise, the end product of photosynthesis, namely oxygen, is utilised in respiration. Ammonia formed by the breakdown of proteins and other nitrogenous compounds is utilised by the plants in the synthesis of other proteins (Fig. 13.4). The following are some of the substances which are exuded by the plants: sugars, proteins, amino acids and other organic acids. Some of the waste materials of metabolism include a variety of compounds belonging to the category of terpenoids, phenols and alkaloids. Various alkaloids and rubber belong to these categories of waste products and are of economic importances.

Plants growing along the sea coast possess structures and mechanisms for the excretion of salt from the leaf surface. The salt is finally removed from the leaf by the action of wind and water. The aquatic plants excrete the waste substances into the surrounding water.

The metabolic waste products are sometimes stored in the plant. They are stored in some plants in the form of crystals in the cells or confined to the vacuoles or stored in the bark. In the tree species the heart wood serves as a reservoir of waste products. Leaf shedding or fall is a common phenomenon in plants and several metabolic and mineral waste substances are disposed off in this manner. Shedding of the bark by tree is a similar phenomenon.

You have learnt in the chapter on circulation that water and dissolved nutrient elements are absorbed by the roots of the plants. It is of interest to note that healthy roots exude into the soil a variety of organic substances including carbohydrates, amino acids and organic acids. These are known as root exudates and form the substrates for microbial activity in the soil They also influence the qualitative and quantitative changes in the microorganisms around the root zone in the soil.

TEST ITEMS

1. Why is the process of excretion important for living organisms?
2. How do plants get rid of the metabolic wastes?
3. Name the waste products that are formed in the plants during photosynthesis and respiration.
4. What are the different excretory products of man?
5. What are the various organs of excretion present in man?

CHAPTER **14**

Movement and Locomotion

1. All living organisms show some type of movement.
2. Movements are easily seen in animals.
3. In the simplest animals movement is merely a streaming of the protoplasm.
4. Movement in multicellular and higher animals is brought about by muscles.
5. Among the plants, some algae move about in water. Mobility in multicellular plants is limited to the male cells during reproduction. Plants also show limited movements of their parts in response to light and gravity.

ALL living organisms show some kind of movement. Animals have the ability to move freely. Movement can be seen clearly in animals since they possess definite organs of locomotion. Plants and animals are generally differentiated on the basis of their ability to move or the absence of it. Though movement is quite common in plants it is not always apparent.

Most animals move from place to place in search of food and to escape from their enemies. Animals showing such locomotion are described as motile. Locomotion in animals is accomplished in a number of ways.

LOCOMOTION IN PROTOZOA

Let us consider the locomotion in the protozoans like amoeba and paramoecium. Amoeba moves about putting forth false feet called pseudopodia which are transitory in nature. (Fig. . 14.1). Amoeba covers a few centimetres per hours. Paramoecium has hundreds of small cilia arising from its body. In the unicellular forms, like euglena, a single flagellum is present. Flagella and cilia represent the projections of cell body and are primarily locomotor structures (Fig. 14.2 & 14.3). The flagella show whiplike motion and cilia oar-like motion. Thus we find that in protozoa flagella, pseudopodia or cilia are concerned with the movement of the organisms.

LOCOMOTION IN MULTICELLULAR ANIMALS

HYDRA

Hydra is a simple multicellular animal. Usually it remains attached to water plants by its closed end called the foot. It serves as a locomotory organ also. At its free end is situated the mouth, which is surrounded by tentacles. The tentacles are tubular slender structures. Some of the cells of the outer layer of the tentacles have the ability to contract. It moves about by alternately elongating and shortening. Locomotion in hydra is brought about by floating, looping or by somersaulting (Fig 14.4). In looping movements the body contracts on one side so that the tentacles grip the support. The foot of the hydra relaxes its hold from the substratum and is drawn towards the tentacles. It attaches to the substratum near the tentacles. The tentacles are then released and the body becomes straight. Hydra also moves by a series of somersaults. It may swim through the water by its tentacles.

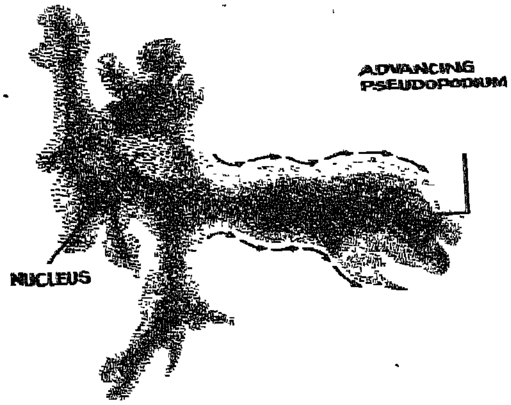


Fig. 14.1. Movement of amoeba through pseudopodia.

EARTHWORM

The earthworm moves slowly using its muscles and bristles in order to get food. During locomotion the earthworm grips firmly the hind part of the body on the soil with the help of the bristles on its under surface. Then it extends its front end. Later the front part of the body is fixed in the soil an the rear part is raised and contracted. The earthworm moves from place to place by repeating this process. In earthworm and other higher animals the property of contraction is highly developed in certain cells only. These cells are called muscle cells and they are specialised for bringing about movement through contraction. These

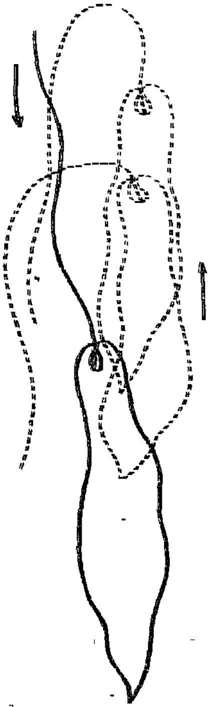


Fig. 14.2. Locomotion in euglena.

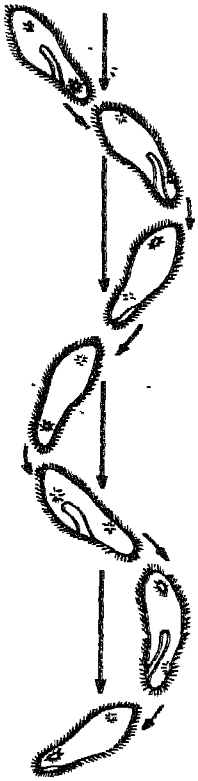


Fig 14.3. Locomotion in paramoecium.

muscle cells together with certain amount of connective tissue constitute the muscle.

INSECTS

Insects constitute the largest group of animals. They have a terrestrial-aerial habit. They usually possess two pairs of wings to carry them over long distances in their flight. They have three pairs of walking appendages in the adult stage. Wings of insects beat rapidly. They represent the simple modifications of the cuticle. Insects such as locusts migrate in large numbers. Swarms of these locusts move from one part of the world to another. They are a serious menace to many of the crop plants.

FISH

Fishes are adapted to life in water. They have a streamlined body which facilitates easy movement in water. A fish causes several jerks in water by bending its body and moves forward (Fig 14.5). A fish balances itself in water and controls its movement by the fins on its body. The pectoral fins on the body of the fish work like oars of a boat while the tail fin can be compared to the rudder of a boat. The tail fin is used to change the direction of movement.

FROG

Frogs are the most common amphibians showing two phases of lives. The young tadpole lives in water and the adult frog moves on the land and in water. The movement of the tadpoles in their early stages is similar to that of fishes. In frogs the hind limbs are long and strong. Frogs swim with the help of hind limbs. The webbed feet of frogs push the water backward and this causes the forward movement of the frogs. Their movement on land is caused by a series of leaps.

REPTILES

The bodies of the reptiles are covered with scales. The digits are provided with claws. The reptiles show a crawling motion. Snakes and the lizards belong to this group. They are slow moving. The snakes are limbless reptiles.

BIRDS

Birds are feathered bipeds. Their forelimbs are converted into wings. They have a pair of walking appendages. Birds are adapted for flying long distances. The structural features of a bird are extremely suited for its flight in the air. Their wings are modified forelimbs with flesh and bones covered with feathers. They

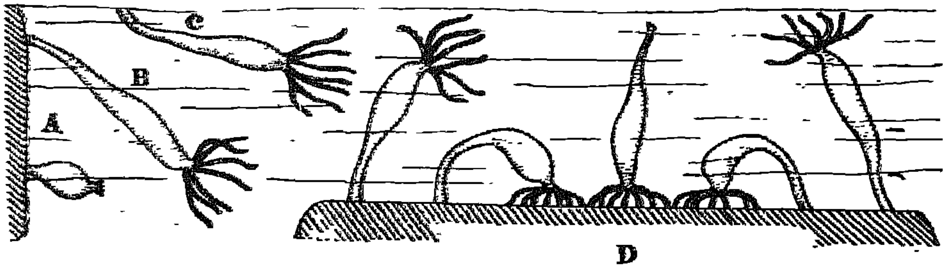


Fig. 14.4. Movement and locomotion in hydra ; A. Contracted; B. Expanded; C. Floating and D. Somersaulting.

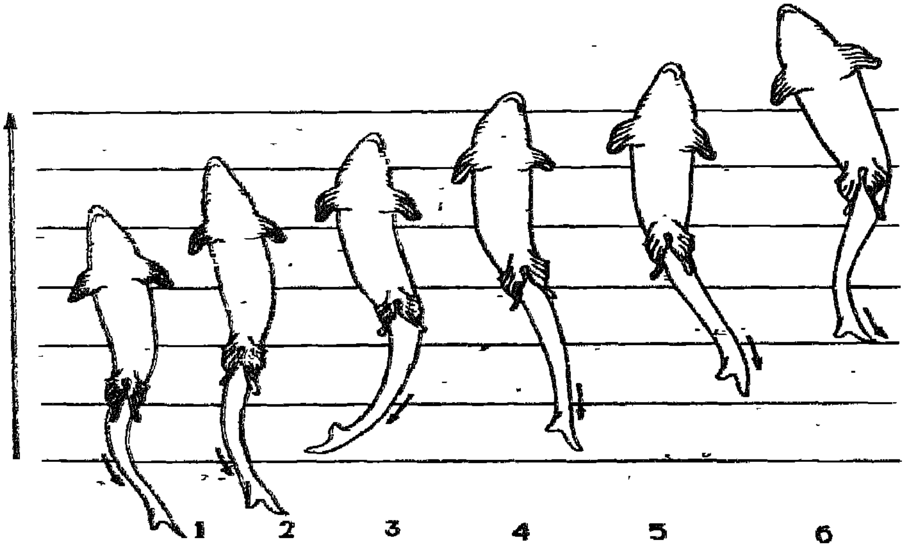


Fig. 14.5. Successive strokes for forward movement of a fish.

have normally short tails bearing feathers. The tails assist in steering the birds during flight. The movement of birds depends upon the strong muscles of the breast. Birds fly over long distances primarily in search of favourable environments where food and breeding facilities are available. Thus birds move periodically from one region to another and come back to their original region. This phenomenon is known as bird migration. The jungle fowl migrates all the way from the Himalayas to the Nilgiris covering a distance of about 2,200 km each way to escape the hardship of severe Himalayan winter. Several other birds are known to migrate from various foreign countries to India to escape severe winters. The bird migration is mostly north to south and back.

MAMMALS

Some of the largest animals living today belong to this category. For example, the elephants on the land and the whales in the sea are mammals. Many mammals generally use their hind-limbs as well as the fore-limbs for movement. Quick moving animals walk or run on their toes and keep their wrist and ankle raised highly above the ground. Some of the mammals like horses and cheetah can attain very high speed on land. The cheetah can run at the speed of 100-110 km/hr.

Bats are winged mammals and can fly. The wings of bats move with the help of powerful breast muscles. They move about in the night and have very poor eye sight. The bats have a remarkable echo apparatus, a radar system, to choose their directions of flights and locate and catch the insects. The bats have sensitive ears which can pick up the supersonic sound waves. Monkeys use both hind-limbs and fore-limbs in their movement. Man having assumed the upright posture is entirely dependent upon the hind-limbs for his movement. Whales in water swim with the help of paddles which are modified fore-limbs.

The bulk of the muscles in the human body or, as a matter of fact in any vertebrate, are concerned with the locomotory movement besides providing support to the body. They are all striped voluntary muscles (Fig. 14.6). The other types of muscles in the human body are the smooth involuntary muscles and the cardiac muscles are concerned with other movements, but not with locomotion.

In all the vertebrates and many invertebrates with a skeleton, the locomotory movements are not brought about directly by the muscles alone. The contraction and relaxation of these muscles move the bones or the skeletal parts and this skeletal motion produces the general movement of vertebrate animals. Therefore, these muscles are called skeletal muscles. The slow creeping movements of an earthworm are entirely due to muscle activity while the creeping movements in a snake

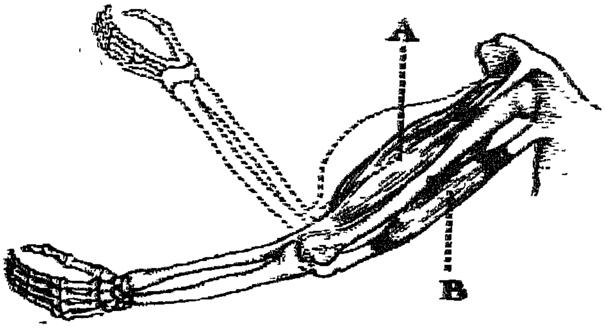


Fig. 14.6. Voluntary muscles (A and B) in the arm of man.

involve the ribs and ventral scales besides the muscles.

For affecting the movement of a skeletal part generally a pair of muscles is necessary. One of the pair, through its contraction distorts the position of the skeletal part generally through flexion. This is the flexor muscle. The other member of the pair, through its contraction restores the skeletal part to its original position generally through extension. This is the extensor muscle. Thus the two members of the pair work antagonistically for affecting the movement of the skeletal part.

For locomotory movements to be executed in a vertebrate, muscle and skeletal elements alone are not sufficient. The contractions and relaxations of the different muscles at different joints must all be brought into harmony. This is what is called coordination. This is brought about by the nerves involved in the reflexes concerned.

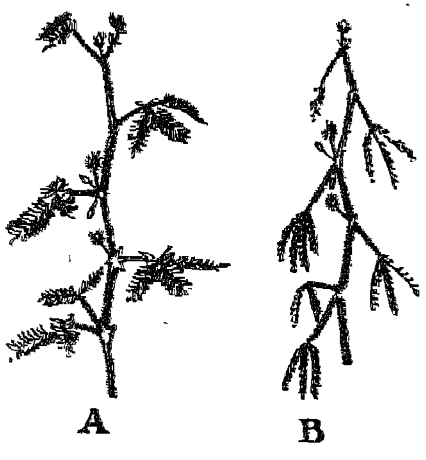


Fig. 14.7. 'Touch-me-not' plant : (A) before and (B) after it is touched.

MOVEMENT IN PLANTS

With the exception of some algal forms almost all the plants are anchored to the soil and are immobile. It is of interest to note that mobility in higher plants is restricted to spores and seeds. Some algal forms, like chlamydomonas and volvox living in water show mobility by means of a pair or more of flagella. In terrestrial plants, namely the Bryophytes, Pteridophytes and Gymnosperms, mobility is restricted to the male cells, namely the spermatozoids. They are ciliated and move about in a medium of water. They show response to changes in temperature, light, etc.

In higher plants, the angiosperms, even the male cells have no motility. They are carried to the vicinity of the egg in the pollen tube formed from the pollen grain. Although it is not always apparent, movement is quite common in higher plants. When a flower opens its parts are spread out by a slow movement. The leaves of the sensitive plant, 'touch-me-not' fold up when touched by hand (Fig. 14.7) and open again after sometime. The bending of plants towards light is another example of movement. This can be usually observed in seedlings germinating from seeds in the dark. Plants also show corrective movement in response to gravity. The roots usually grow downwards (positively geotropic); the shoot grows upward (negatively geotropic). In whatever manner the germinating seeds are planted the roots and shoots assume correct positions by curvature.

TEST ITEMS

1. What is the need of locomotion in animals ?
2. Name the structures concerned with locomotion in the following :
   (i) Amoeba; (ii) Paramoecium; (iii) Earthworm: (iv) Insect; (v) Fish; (vi) Reptile; (vii) Bird; (viii) A mammal.
3. What are the structures that show movement in higher plants ?
4. Name any two movements shown by plants in response to light and gravity.

CHAPTER **15**

Reproduction

1. Reproduction is an essential life process which allows a species to perpetuate.
2. Reproduction is not merely a process of multiplication but an elaborate mechanism through which the genetic character of one generation is passed on to the next.
3. Sexual reproduction is the mechanism by which variations are produced.
4. The reproductive mechanism is simple in certain organisms but complicated in others
5. In higher animals, including man, the reproductive organs also act as endocrine organs

ONE of the important characteristics of living organisms is their ability to reproduce their kind This is essential for the perpetuation of any species Each organism, either a plant or an animal, lives for a fixed span of life. Death may take away the individual but the individual maintains its continuity through reproduction. Reproduction is an answer to death. Other characteristics of life may have some parallel in the non-living world, but reproduction is a unique character of the living

TYPES OF REPRODUCTION

Living organisms reproduce in two different ways, by (1) asexual reproduction and (2) sexual reproduction.

In asexual reproduction the same individual multiplies In sexual reproduction two individuals are invariably involved in reproduction. The offspring arise from the fusion of two cells, each contributed by one of the two parents

ASEXUAL REPRODUCTION IN UNICELLULAR ORGANISMS

Fission is the most common method of asexual reproduction among unicellular organisms The organism divides itself into almost two equal halves. Each of these then grows into full size and the process may then be repeated

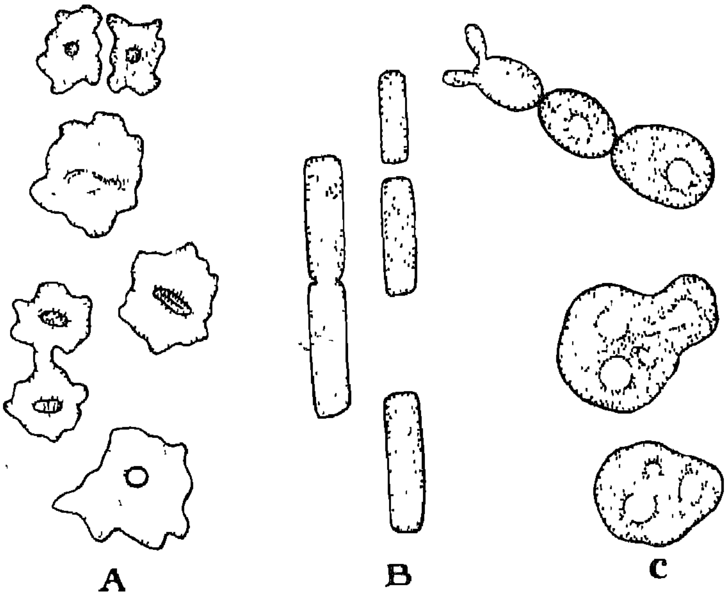


Fig 15 1 Multiplication by asexual reproduction in (A) amoeba, (B) bacterium and (C) yeast

Bacteria and amoeba reproduce by this method (Fig 15 1)

Asexual reproduction in yeast cells is accomplished by budding (Fig. 15.1). In the yeast cell a bulbous projection appears. This is known as the bud. The nucleus of the parent cell divides and one of the daughter nuclei passes into the bud Finally this outgrowth detaches from the mother body. This process of budding is repeated under ideal conditions

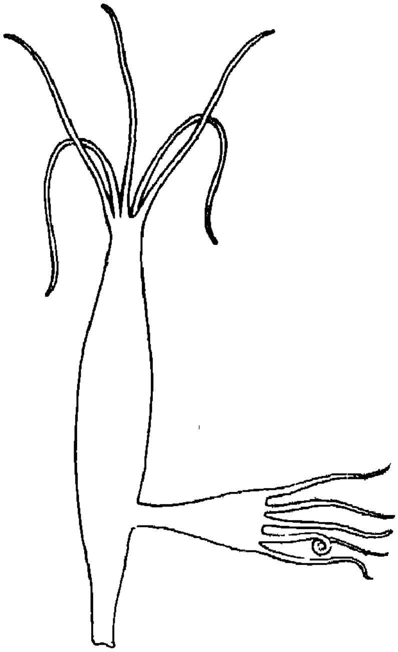


Fig. 15.2 Budding in hydra.

ASEXUAL REPRODUCTION IN MULTICELLULAR ORGANISMS

Budding. The term budding is also used to describe asexual reproduction in multicellular organisms A bud may be formed in hydra as an outgrowth of the body wall (Fig. 15.2) The bud grows into a small hydra and breaks off from the parent to become a new individual

Fragmentation. In sponges, some coelenterates, flatworms, etc., when a part of the body of the organism is severed, the part can regenerate into a new individual.

In the thallus of *Riccia*, and filamentous alga *Spirogyra* fragmentation is very common, where each of the fragments grows into a new individual.

Sporulation. In plants which do not produce seeds, the formation of spores is a common method of reproduction. These spores are light in weight and very small in size. They have thick walls, which enable them to withstand the adverse conditions in the environment In several algae, a single individual cell produces four to eight motile spores called zoospores. Under favourable conditions each of them develops into an alga. In higher forms of plants these spores are enclosed in a capsule In some fungi like mucor (Fig. 15.3) spores are produced prolifically.

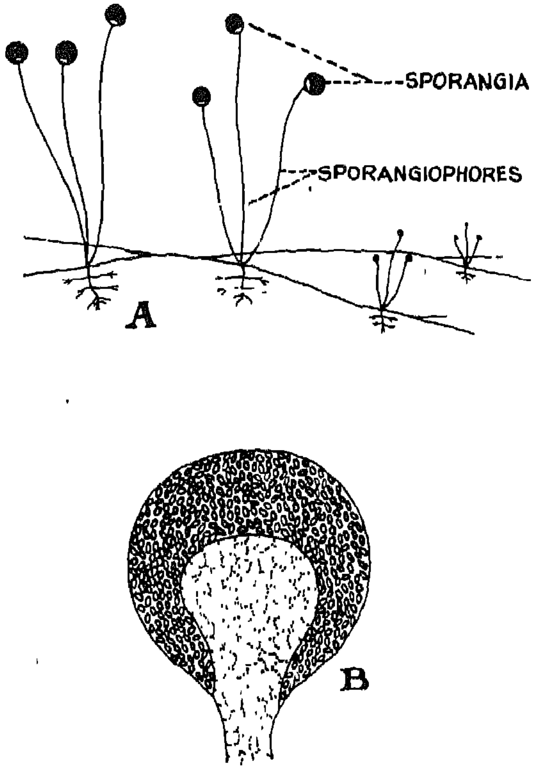


Fig 15.3 A Formation of sporangia in asexually reproducing mucor B An enlarged view of a sporangium showing sporangiophore and spores.

Vegetative propagation Ornamental and orchard plants are propagated commonly by cutting, grafting and layering. The daughter plants produced by these methods are identical with the parents in all respects.

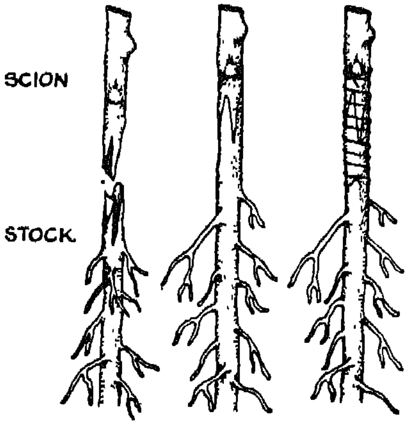


Fig 15.4. Successive stages of grafting in plant

Grafting. Nurserymen grow mango and orange trees by planting seeds. They raise their seedlings not for their fruit but for a strong root system. When the plant is firmly established the portion of the plant above the ground is removed. A twig taken from a mature tree of the desired variety (scion), is inserted in a notch in the cut stump (stock) (Fig. 15 4). The successful development of the graft depends on the accurate mitotic activity of the cambium cells of stock and scion The scion obtains all its requirements of water and minerals from the root system of the stock The fruit that will be produced eventually will be identical to the fruit of the tree from which the scion was taken Grafting is a very common horticultural method of propagation of many fruit trees The desired fruit qualities are maintained by grafting practices

Cutting Propagation by cutting is the only method of propagation in rose, coleus, pothos and bougainvillea plants. When cuttings of these plants are placed in moist soil they strike roots and grow into new plants Layering is the common method of propagation followed in some ornamental plants, e g. jasmine and rose plants In this method one or more branches of a plant are bent close to the ground and covered with moist soil. Some time later the branches strike roots and produce plantlets These plantlets can be separated from the parent as new individuals. New plants develop from the leaves of *Bryophyllum* (Fig 15 5) and leaf cuttings of *Begonia.*

SEXUAL REPRODUCTION IN ANIMALS

In sexual reproduction the offspring arise through the fusion of two specialised cells called gametes. Generally, one of the gametes is active and smaller in size This is the male gamete The other gamete is generally passive and larger in size This is the female gamete or the egg If an organism produces male gametes alone it is called a male If it produces female gametes it is called a female. If it produces both the gametes it is called a hermaphrodite In malarial parasite two individuals participating in sexual reproduction are dissimilar in appearance So is the case with a cockroach or man. In these cases the individuals are said to be unisexual. But in earthworm and hydra the male and female reproductive systems are present in one and the same individual. Therefore, hydra and earthworm are bisexual But a given earthworm or hydra produces at a given time only either male or female gametes Thus at a given time it can behave as a functional male or functional female Therefore even in these bisexual animals, unless a functional male and functional female are present reproduction cannot take place

The male gamete is often called the spermatozoon and the female gamete the egg or ovum (Fig. 15 6) The fusion of spermatozoon produced by one individual with the ovum produced by another individual is called cross-fertilization. So when the sexes are separate either anatomically or functionally, cross-fertilization is the rule in this kind of reproduction. Naturally the offspring gets the characters of the paternal parent through the spermatozoon and the characters of the maternal parent through

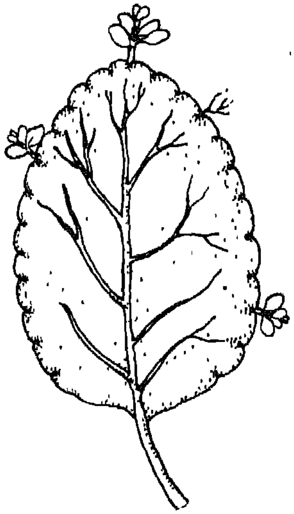


Fig. 15 5 Vegetative propagation from a leaf of *Bryophyllum* Each of the notches along the margin of the leaf has the potentiality to form a new plant the ovum Thus the offspring looks different from either parent

The males and females have different sexual characters. They also show peculiar reproductive behaviours Cross-fertilization is ensured through close approximation of the male and female parents. This is possible as the animals are motile In animals like fishes and frogs the two parents come together and shed their gametes into surrounding water. The spermatozoa fertilize the ova in water This is called external fertilization In insects, spiders and mammals the spermatozoa are deposited by the male inside the body of the female. For this purpose the male has an intromitant organ The spermatozoa fertilize the ova inside the body of the female This is internal fertilization.

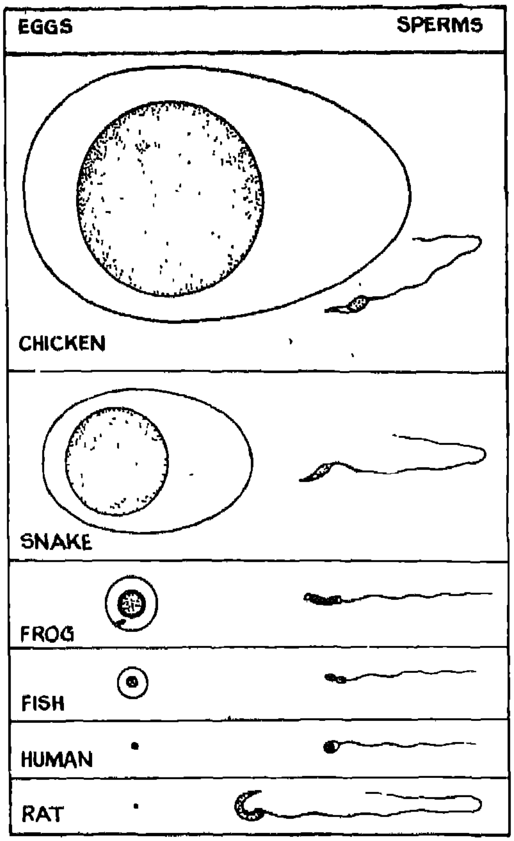


Fig 15 6 Eggs and sperms of some animals Note the relative size difference between the eggs of chicken, snake, frog, fish, human and rat

The spermatozoa are very small and active cells which swim about and go in search of the large, passive ovum. To ensure fertilization a large number of gametes are produced by the parents This is more so when the fertilization is external because the chances of the spermatozoa meeting the egg in surrounding water are less than inside the body of the female

Though many spermatozoa approach and contact the egg, only one finally fuses with it The fusion product is called zygote. It is impermeable to other spermatozoa. The spermatozoon and the ovum have each a haploid set of chromosomes, as they are produced through meiotic division Therefore, the original diploid number of the chromosomes is restored in the zygote The zygote develops into the offspring

The development of the zygote may be facilitated, specially in higher organisms by the maternal parts of the reproductive system. These parts act as endocrine glands and secrete the hormones

SEXUAL REPRODUCTION IN PLANTS

In several angiosperms or the flowering plants the flowers are bisexual or hermaphrodite. They contain both male and female reproductive structures The stamens produce the microspores or the pollen grains. The ovules in the gynoecium produce the megaspores The microspores and megaspores are formed in the respective structures after the meiotic division So they contain half the number of chromosomes of a parent

Pollen grains (microspores) are carried by various agents like insects, air and water to the stigmatic surface The male cells are formed inside the pollen grains and they are carried in the pollen tube through the style (Fig. 15 7) The megaspore develops into an embryo sac which contains the egg The male cell fuses with the egg and forms the zygote. After some time the zygote ultimately develops into the embryo, which in course of time develops into a new plant.

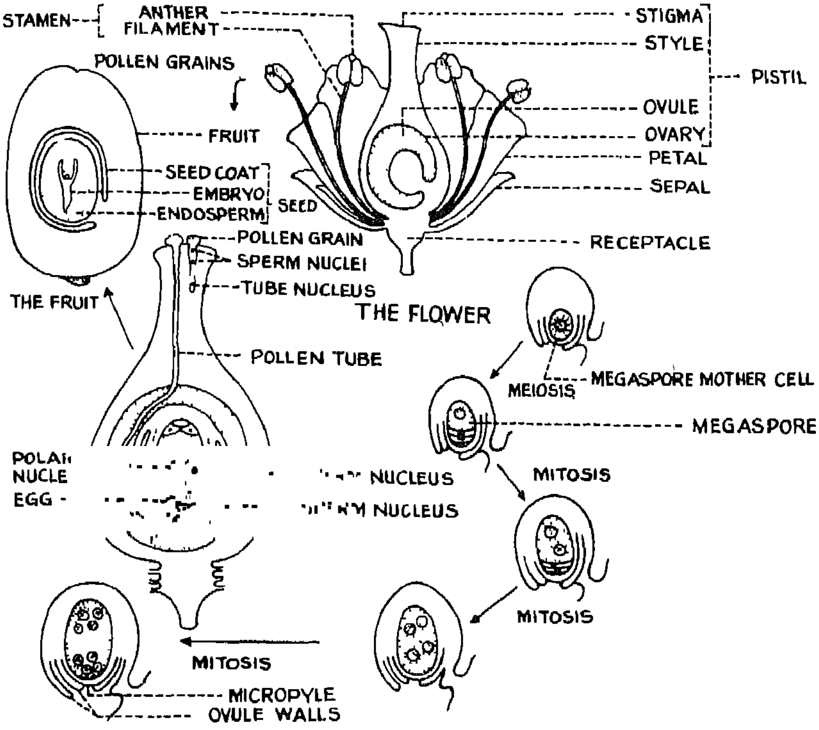


Fig 15 7 Structures and phenomena associated with sexual reproduction in plants

TEST ITEMS

1. Put a (√) mark against the correct statements
   (i) · Reproduction is an essential life process (   ).
   (ii) Reproduction occurs only in animals (   ).
   (iii) Sexual reproduction is seen only in higher organisms (   ).
   (iv) Reproduction is not necessary for the individual but important for the population (   )
   (v) Sexual reproduction involves participation of two individuals (   )
2 What are the different types of asexual reproduction?
3 Why is cross-fertilization more important than self-fertilization?
4. What do you understand by hermaphrodite? How does cross-fertilization occur in hermaphroditic forms?
5. What are the essential requisites for sexual reproduction?

CHAPTER **16**

Growth And Development

1. There is a set pattern in the development of all plants and animals.
2. Growth and development are sequential process.
3. The overall form of an organism is the result of interactions between genotype and environment.
4. The key word in development is 'change' which operates till the death of the individual.
5. The various events that occur during growth and development have essentially a cellular basis.

You are well aware of the phenomenon of growth. The development of the seed into a mature plant is a remarkable process (Fig 16 1). You have also observed the growth of man or animal from the new born stage towards adulthood (Fig. 16.2). In this context, you must have also noticed that individuals pass from one stage to another during the course of life and show increase in size. This entire process of transformation of an individual organism is an important area of biology and is studied under growth and development. The process of growth involves increase in the mass of cytoplasm indicated by cell size and cell number.

The process of growth and development is remarkable for its orderliness. An organism passes through a well-defined series of events which lead to the sequential development of form and physiology, characteristic of a particular species. A mango plant develops shoot and root system unique to itself with a set type of roots, branches, leaves, flowers and fruits (Fig. 16 3). On the basis of these characteristics you can always distinguish a mango plant from a banana plant. This uniqueness or identity of form, as you know, is due to the distinctive genetic constitution or 'blueprint' possessed by each species and the modifying effects of the environment. Similarly, a cow can always be distinguished from a buffalo, no matter how much alike the two may look to be.

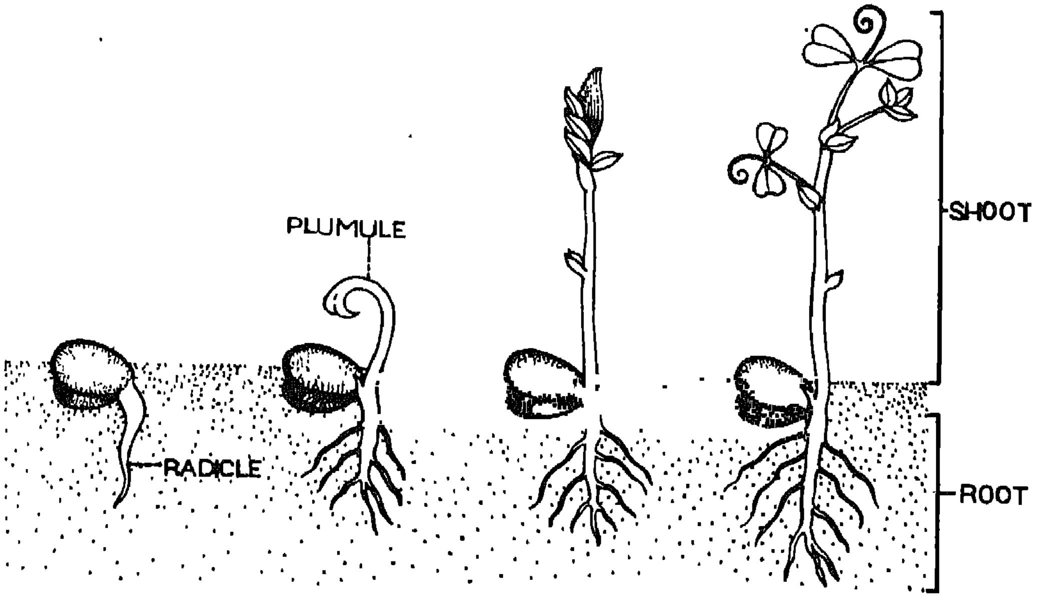


Fig 16 1. Growth and development of a plant

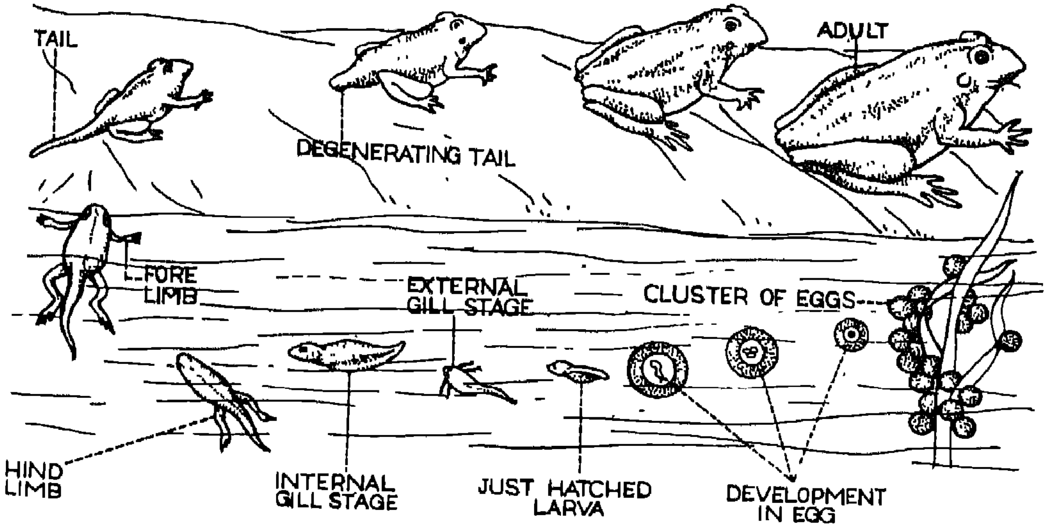


Fig 16.2 Development of frog.

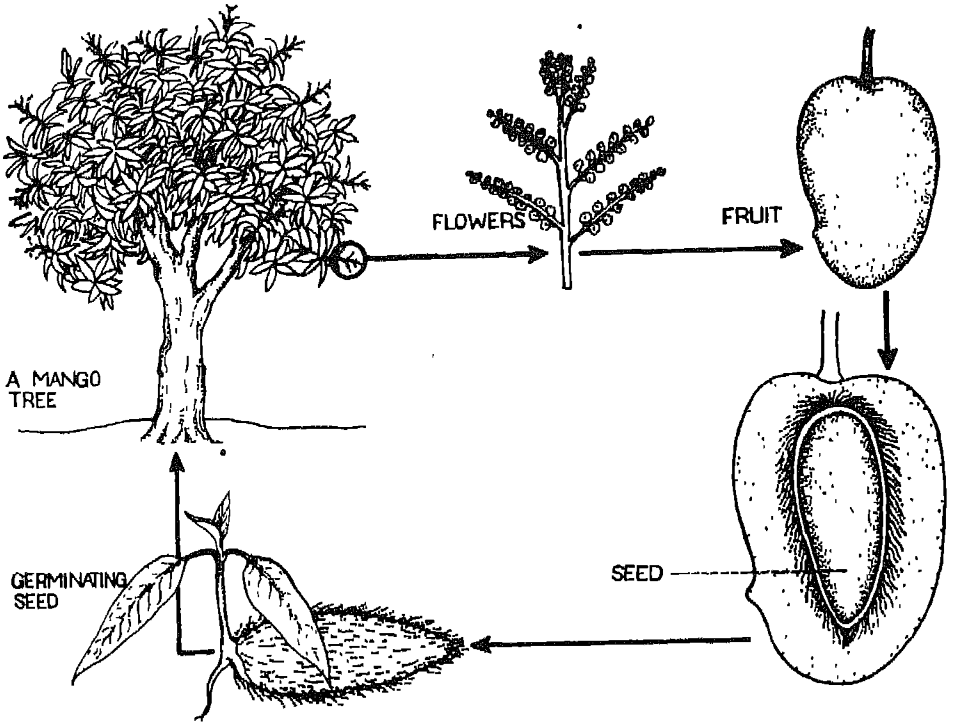


Fig 16 3. Life cycle of a mango tree

A number of characteristics of living organisms are influenced by the environment Despite the same genetic constitution, the forms of similar organisms raised in different environments may differ significantly. For example, a plant grown in shade will differ significantly from another of the same variety grown in light. As a matter of fact, variation in any of the major factors of environment will bring about noticeable differences in the form and physiology of organisms This applies to all organisms but is much more pronounced in plants You can thus generalise that the overall form of an organism is the result of interactions between its genotype and the environment in which it grows.

You are already aware of the different types of reproduction in the living world In the unicellular organisms, the daughter individual synthesises new materials and develops into an adult. In the multicellular organisms, where sexual reproduction occurs, development begins from the single-cell stage called the zygote From this single cell stage, through a series of events, the adult form appears Such changes continue even after germination in plants and hatching or birth in animals

You know that in the animals like cow, cat, tiger and man, the embryo develops inside the body of the mother. In other groups like fish and frog, the development takes place in the external environment In birds the development within the egg is external but it needs a specific temperature. Such temperature is provided by the parent birds who alternately sit on the eggs This is called incubation.

Fig 15 6 shows the structure of the egg cells in frog, hen and man In Fig 16.4 you find the different developmental stages of chick and man. Is it not interesting that all animals have more or less a common and simple beginning? Fig. 16 5 shows how to dissect out a chick embryo. Have you noticed that in the early stages of development, the embryos of different animals look alike? The diversity appears only in the later stages of development What evidence is provided by these fundamental similarities of embryonic stages? Can you guess? How are the different organs produced from a single cell? How are the different organs formed in particular position? The answers to all these questions depend upon the physical basis of development.

Only in recent years man has been able to understand this basis of development. It has now been understood that all changes during the development are essentially cellular events It is of interest to note here that the unifying feature of plant and animal structures lies in the basic cell structure. There are five phases of cell development They are (1) cell division, (2) cell elongation or extension; (3) cell movement, (4) cell differentiation and (5) cell death.

Of these five, cell elongation is entirely a feature of plant development It is now understood that changes do not cease with the birth of the new individual If you look at the photographs of your childhood you will find that you have changed a lot You know well that you will change further. All these changes are due to cellular activities Therefore, the scope of the study of development does not end with the study of embryonic or larval stages It includes the entire span of an individual's life from the formation of germ cells to the death of the individual Similar cellular events are repeated during regeneration For this reason the regenerations of different animals (Fig 16 6) are extensively studied to understand these cellular events. You may like to know about each such cellular event

CELL DIVISION

The essential requisite for the development of an individual is the proliferation of cells The cells proliferate by cell division called mitosis The rate of mitosis is high in the early stages of development Upto a stage, mitosis is also synchronous, that is all the cells divide at the same time Gradually the occurrence of mitosis becomes irregular that is the cells in some parts divide rapidly than those in other parts. In plants, mitosis operates almost throughout the life in the growing stem and root apices But in animals, where growth is restricted, the occurrence of mitosis is also restricted For example, in an adult man, mitosis takes place in the epithelial tissue of skin, digestive and reproductive tracts, in the bone marrow to form blood cells and in the testis and ovary But in most other parts, the same cell continues to work without replacement The factors underlying cell division are not yet completely understood

CELL ELONGATION

This is found most commonly in plants After the cell division, the surface area of the cell increases considerably for growth to take place The cell absorbs water and stretches the already softened cell wall Along with the stretching of the wall, a new cell-wall material is synthesised The surface area of the wall is increased In the case of plant cells, therefore, water absorption and synthesis of cell wall are the important aspects of cell elongation

CELL MOVEMENT

During development, considerable movement of cells takes place. These movements

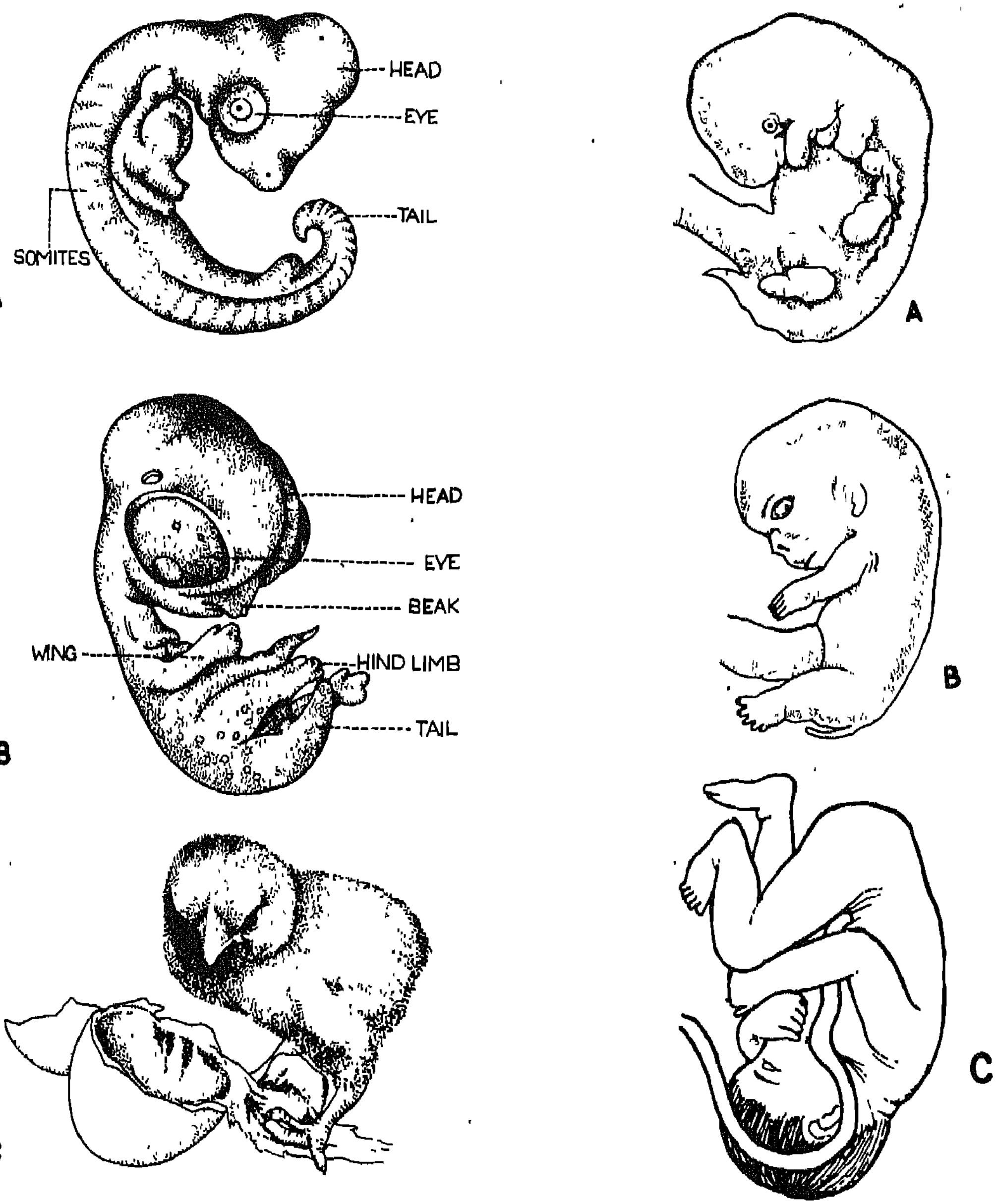


Fig 16.4 Some stages of development of chick and man

are called morphogenetic movements because they are responsible for the development of the forms Through this movement, the cells take up their proper position to develop further. Cells that are destined to form the face move to the anterior and while cells destined to form the tail move to the posterior end. Thus the cells are sorted out and transported to their destina-

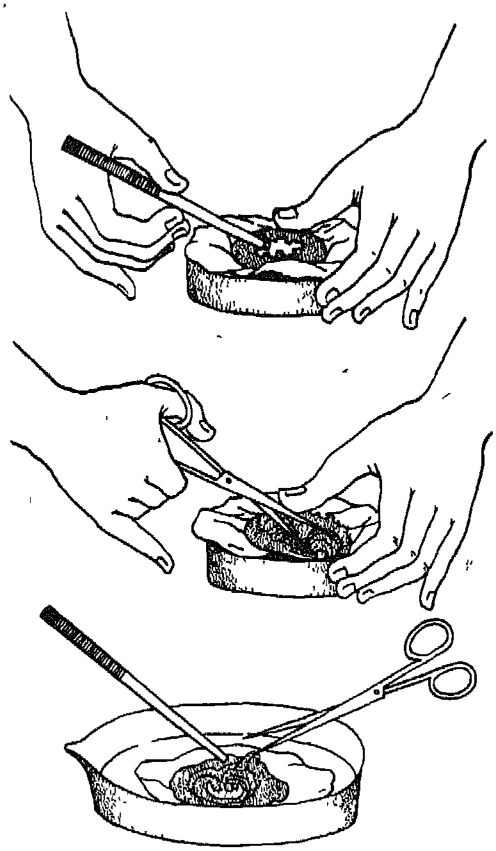


Fig 16 5 How to dissect out a chick embryo

tions. These movement are integrated in space and time A group of cells move to the right place at the right time so that it can interact with another group. One of the most important tissue interactions is called induction By induction we mean influencing and changing the fate of a group of cells for proper development. How can the cells identify their positions ? How exactly the cells move ? Why do not they move after reaching their destined site ? These are a few of the many unanswered questions about the cell movement.

CELL DIFFERENTIATION

In a developing embryo, all the cells change and attain a particular form to perform specific functions. This transformation is called *cell differentiation.* A cell, once differentiated, that is, once it has become either a muscle cell or a nerve cell, looses its power to be transformed into any other cell type. Why does a cell differentiate ? In plants the cells derived from the meristematic tissue undergo differentiation in structure and function like the palisade cells specialised for photosynthesis or the conducting tissue specialised for translocation. Can a cell, destined to be a muscle cell, change into any other cell type ? The scientists have been trying to solve this riddle of cell differentiation for quite some time.

CELL DEATH

The young cells become mature in the course of time, perform their function and ultimately die. These dead cells are replaced in the individual by new cells. Thus a large number of cells die even when the individual is alive. You never feel that almost every day hundreds of cells of your skin are sloughed off and are replaced by new cells. Your old blood cells are replaced by new ones after every six weeks. Such cell death also occurs during development It is now understood that ageing and cell death is a necessary part of the development cycle. In the case of a few trees they have the capacity to survive for ages, well over a few thousands of years. Plant tissues grown in culture solutions under controlled conditions survive for several years.

GROWTH IN PLANTS AND ANIMALS

The growth in all living organisms follows a set pattern Initially the growth is very slow

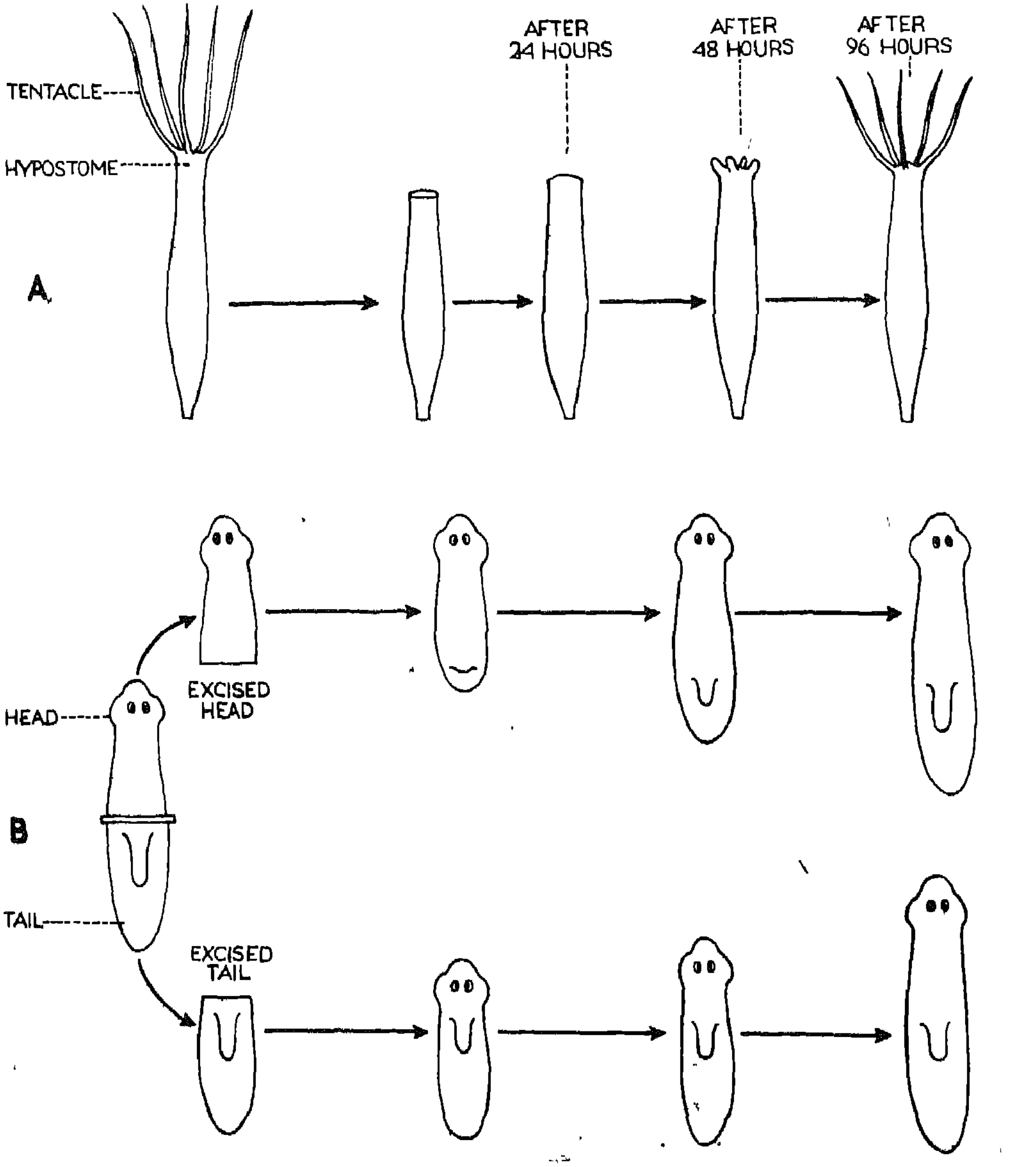


Fig 16 6 Regeneration in (A) *Hydra* and (B) *Planaria*

which is followed by a rapid phase. After the rapid phase, the growth rate slows down and after some time no growth is observed.

You may select some flowering plants in your home or school garden at very early stages of growth. Measure their lengths every week Plot a graph of the length against time.

Let us follow the growth pattern of a plant or an animal from the initial to the final stage If we plot its size at various time intervals, we

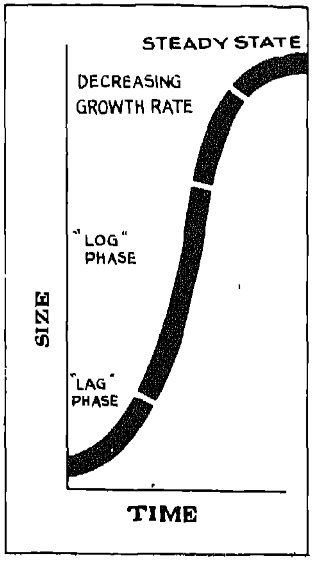


Fig 16.7 All cells, organs, organisms and populations describe a 'S' or sigmoid growth rate

find the growth-curve shows a typical 'S' shape and is called a sigmoid curve. This curve is typical of all cells, organs, organisms, populations of plants or animals and men (Fig. 16.7)

The growth in all organisms occur in length, breadth and in weight. The plants continue to grow throughout their life but in animals this growth is restricted. Growth in plants is described as unrestricted. It may be noted that there are two active regions of growth in the plants; these are located at the stem and root apex. In the beginning the growth is uniform. But gradually, the growth becomes irregular and results in a disproportionate body. In the course of growth, the specific proportion of the body is again restored. In both plants and animals, most aspects of growth and differentiation are under specific control of chemical substances. These chemicals are called hormones. The hormones occur in extremely small quantities, exert their regulatory effects and are transported from the site of synthesis to the place of action. You are already aware of the different hormone-producing endocrine glands in animals. The plants have four major classes of naturally occurring hormones or growth regulators, these are auxins, gibberellins, cytokinins and abscisic acid. The modes of action of growth regulating substances are complex and interlinked with each other. The orderly growth and development of the plants and animals is regulated by the growth hormones present in them. Apart from these factors, environmental factors like light, water and temperature exercise considerable influence on growth and development. The hormones serve as a link between the environmental factors and the genetic constitution or the blueprint of the plant or animal.

TEST ITEMS

1. What are the important features of growth in a plant ?
2. How does animal growth differ from plant growth ?
3. What is the significance of cell death and cell movement in development ?
4. What is cell differentiation ? Explain with an example.
5. What is the nature of substances which control the growth in plants and animals ?

CHAPTER 17

Control and Coordination

1. Unicellular organisms coordinate their different activities and respond to various stimuli.
2. Plants do not have a nervous system, yet they possess an elaborate chemical coordination.
3. Various chemicals are involved in coordinating the activities in an animal body, the most remarkable are the hormones.
4. Each hormone is required in extremely low quantities; and increase or decrease in the specific quantity is harmful to the individual
5. Nerves are special cells for control and coordination.

You have studied that each living organism carries out a number of vital activities. For each function there is a system made up of several organs Each organ, in turn, is made up of thousands of cells Though functions are divided, when you come to the cellular level, you find that all cells carry out the functions like nutrition, respiration and excretion. Moreover, an organism as an individual meets various stimuli from the environment. The response must be given as a whole. For effective living, each individual must have devices to control and coordinate different activities.

In the unicellular organisms, the single cell while carrying out the vital activities also controls and coordinates them. It shows positive response to some stimuli (gets attracted towards food) and exhibits negative response to some (moves away from harmful objects). The multicellular organisms have a separate system to carry out these functions. In plants, this coordination is entirely chemical, but in animals, two kinds of coordination—*chemical coordination* and *nervous coordination*—are present.

CHEMICAL COORDINATION IN ANIMALS

Hormones control the growth and development in all animals. In insects a number of hormones which control the changes during development are known Fig 17 1 shows the different endocrine glands in man. All these endocrine glands work in unison and the effect of one is linked to that of the other Moreover, all endocrine glands work in close cooperation with the nervous system Before entering into the details of the functions of hormones in animals, let us discuss some other kind of chemical coordination which exists in animals. You have learnt in the earlier chapter on respiration that during a strenuous exercise, the muscle cells liberate energy Rapid use of oxygen by these cells causes incomplete breakdown of the reserve substances Such incomplete breakdown results in the formation of a chemical substance called lactic acid The increased concentration of lactic acid tends to alter the pH of the blood and thus it stimulates the nerve centre. This stimulation excites the rate of breathing and excess oxygen is supplied to complete the breakdown. Lactic acid is one of the many chemicals which operates within the body of an individual.

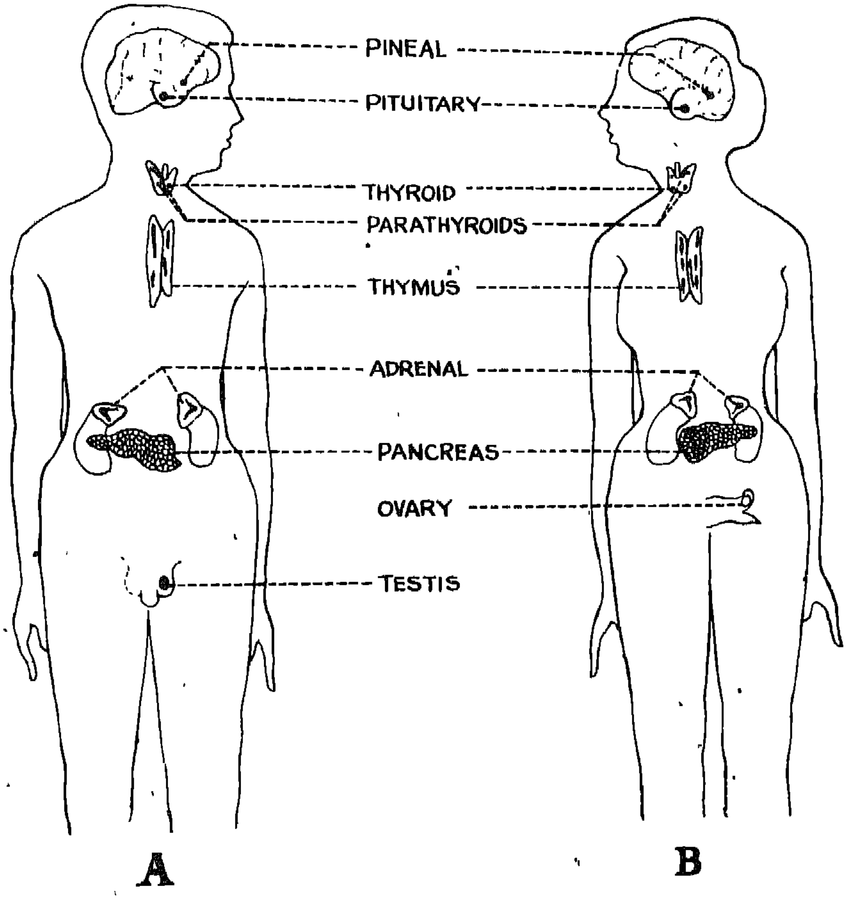


Fig. 17.1 Location of various endocrine glands in (A) male and (B) female bodies

HORMONES

Hormones vary greatly in their chemical composition Many of them are steroids, but some may be proteins and even amino acids Each hormone creates specific physiological influence on different cells to bring about a particular response Some hormones are accelerative, some inhibitory For the normal working of the body, a particular hormone is needed in a specific quantity. The growth will be modified if the quantity increases or decreases One type of gland produces a hormone or hormones for different functions. For example the pituitary gland produces hormone to control growth and sexual maturity. The same gland, immediately after the child birth activates the flow of milk in the breasts of the mother Different hormones in vertebrates control important life processes like growth, development, formation of skeleton, digestion and reproduction, whereas, in the invertebrates they control moulting, metamorphosis and migration.

Hormones from the endocrine glands are poured directly into the blood stream They flow all over the body, but affect only the cells of a specific region How does a cell identify the hormone which is meant for it?

For a long time scientists could not make out how this is done The answer came with the understanding of the role of a chemical substance called cyclic AMP (adenosine monophosphate) in the cell

NERVOUS COORDINATION

You are already familiar with the general organisation of the nervous system. The nervous system not only controls the working of the internal organs, but also the response to the external stimulus It has the following components.

1 *Receptor organs* to act as the entrance of different stimuli (can you name some receptor organs?)
2. *Sensory pathways* to transmit messages

TABLE 17 1

IMPORTANT HORMONES PRODUCED IN MAMMALS AND THEIR PRINCIPAL EFFECTS

HORMONE	*Produced by*	*Affects principally*
Thyroxin	Thyroid	Growth and metabolic rate
Insulin	Pancreas	Sugar metabolism
Adrenalin	Adrenal medulla	Blood pressure
Follicle stimulating hormone (FSH)	Pituitary	Ovarian follicle
Luteinizing hormone	-do-	Ovary, corpus luteum
Growth hormone	-do-	Growth
Anti-diuretichormone (ADH)	-do-	Kidney-urine volume
Oestrogen	Ovary	Female organs
Testosterone	Testis	Male organs
Adrenocorticotropic hormone (ACTH)	Pituitary	Adrenal cortex

for the receptor (what are the different kinds of messages which we receive?)

3 *Modulators* to receive messages and to issue specific instructions (name the modulators in man)

4 *Motor pathways* to carry instructions from the modulators to the different parts of the body for necessary action.

The different muscles and glands which work according to the instructions are called *effectors*

You are already familiar with the appearance of cells which constitute the nervous system The nerve cells or neurons are generally star-shaped or spindled-shaped Each cell has one long fiber called axon and several small fibers called dendrites The dendrites of one neuron remain in close contact with the axon of a neighbouring neuron. These regions of contact are known a synapses The innumerable synapses between the millions of nerve cells form the basis of the nervous system. The most important organ of the vertebrates is the brain This organ has attained maximum growth and complexity in man It has been possible today to map out, different parts of the brain according to there function. But all the regions are interlinked and the coordination of different works is done in the brain itself

REFLEX ACTION

Many functions go on inside our body without the participation of the brain in response to external stimuli These are called reflex actions This way many of the functions are carried out in the body without the knowledge and participation of the brain These reactions are not initiated by the spinal cord but are effected only by the response due to an external stimulus. When the finger is burnt on a flame, or when you suddenly step on a sharp object you withdraw your finger or leg immediately. How does this happen ? In the reaction messages are flashed along the nerve to the spinal cord The spinal cord in turn stimulates the nerve supplying the muscles of the arm or the leg This results in the contraction of the muscles, pulling away the hand or the leg These reactions are performed in a fraction of a second The path travelled by the impulse from the sensory organ to the motor organs is called the reflex arc. The nervous response is involuntary and it occurs even before you are aware of the stimulus In your daily life many actions are carried on involuntarily These are known as reflex actions

Most reflex arcs are much more complicated. They involve many more components There can be chains of reflexes Most of the reflexes are mediated in the spinal cord itself. Then they are called spinal reflexes It does not mean that there are no reflex arcs in the brain For example the wink reflex of the eye lids is the one mediated by a reflex arc in the brain

How are the messages conveyed through the nerves ? For a long time two sets of answers were provided. According to one group, this happened due to a change in the electric charges, but the other group holds that this is due to chemical reactions The advent of electron microscope and introduction of new techniques have helped answer this question correctly. It is now regarded to be an electro-chemical process. When the neuron is stimulated, the message flows as a change of charge, but when it is transferred from one neuron to the other, it passes as a chemical substance

CHEMICAL COORDINATION IN PLANTS

In addition to water, light, carbon dioxide and nutrient elements a plant requires other chemicals for its growth. Different aspects of plant development, growth, leaf fall, flowering and the like are controlled by certain organic substances known as plant hormones Hormones are considered as one of the most important cell coordinating substances in plants.

A hormone is often described as an organic substance, normally effective at very low concentration, that is produced at one locus and may then bring about its profound effect elsewhere. There are four main groups of plant hormones and these are *auxins, gibberellins, cytokinins* and *abscisic acid.* It is the overall balance of these four groups of substances that influences the manner of cell division, cell enlargement and cell differentiation in plants.

AUXINS

One of the representatives of this group of substances is *indoleacetic acid* (IAA) Several other compounds have been synthesised in the laboratory, which have auxin like properties, like 2, 4-D (2,4-dichlorophenoxy acetic acid), NAA (naphthalene acetic acid) which are commonly used in agricultural and horticultural practices as weedicides in extremely low quantities. The auxins are being used in rooting of cuttings and controlling premature fruit drop in orchards. They have several uses in horticulture. When unfertilised flowers are sprayed with IAA, seedless fruits can be obtained

GIBBERELLINS

They are also auxin like substances. The effects of the gibberellins are particularly noticeable on the dwarf strains of plants. Genetically dwarf strains of pea, corn or bean can be stimulated to grow to the size of tall plants by the application of gibberellins at low concentration. They also promote seed germination.

CYTOKININS

Cytokinins play an important role in the expansion and differentiation of leaf tissues. They influence the rate of mitosis and are present in young developing tissues. They cooperate with other plant hormones in regulating growth and development.

ABSCISIC ACID (ABA)

This has been discovered recently. Unlike the other hormones it is a very good example of a hormone that primarily acts as a growth retardent or suppressor of growth. In the life of the plants it promotes leaf fall, regulates stomatal aperture thereby controlling water loss, in inducing bud dormancy and such other phenomena. ABA is the most potent of all the growth hormones

In recent years plant growth regulators are being used increasingly in rooting of cutting, control of pre-harvest fruit drop, control of flowering, in the production of seedless fruits, weed control and several other useful operations in agriculture.

TEST ITEMS

1. Describe why a living organism has devices to control different life activities
2 How does a unicellular organism control its activities ?
3. Name the different plant hormones ?
4. Mention the functions of the following hormones :
   (i) Auxin; (ii) Gibberellin, (iii) Cytokinin; (vi) Abscisic Acid; (v) Thyroxin
5. What is the role of hormones in the invertebrates ?

UNIT—4

GENETICS AND EVOLUTION

CHAPTER **18**

Heredity and Variation

1. No two living organisms are identical. Variation may be environmental or hereditary.
2. The various external and internal features of particular living organisms are called *phenotypes* The genes controlling expression and transmission of the phenotype through generations is called *genotype*
3. Environment may affect the phenotype, but usually not the genotype.
4. The genotypic changes may be due to reshuffling of genes during meiosis, doubling of chromosomal number, increase or decrease of chromosomal number, loss of chromosome segment and mutation of genes
5. Genotypic changes are inherited and can alter the phenotype.
6. Gregor Mendel for the first time formulated laws to explain the mechanism by which the hereditary characters pass from one generation to the next.
7. The success of Mendel was mainly due to his selection of the right experimental material and careful planning of the experiment

You have already learnt about the living cell, organisation of a living body, its relations with the environment and various life processes You also have some basic ideas about the chromosomes and heredity. You know that though the members of a species give birth to their own kind, the offspring show some dissimilarities to their parents and to each other. These dissimilarities in related organisms are called 'variation'. What causes this difference between two individuals related by descent?

CAUSES OF VARIATION

Before we proceed to find answer to this question, it is essential to bear in mind that though all organisms appear different from each other, they are strikingly similar in a number of biochemical processes. In other words, all organisms are similar at molecular level, for the molecules which make them are essentially alike When we talk of variation we are mainly concerned with variations in morphological, anatomical, reproductive and behavioural characteristics of organisms.

Let us analyse the gross external appearance and the factors that are inherited You know that the genes are the hereditary units and that they are transmitted to the offspring during reproduction The genetic constitution of an individual is called *genotype*, while the external appearance, anatomy, behavioural pattern and reproduction make the *phenotype* of an organism After birth, the young ones grow in a particular environment A change in environment may influence their appearance or phenotype But the overall morphology or anatomy, however, remains similar to that of the parents The environment, usually has no influence over the genotype The phenotype, in other words, is the net result of interaction between genotype and environment.

It is obvious from the above that variation may be due to environment or heredity In order to understand this, you may try the following experiments These experiments will take a long time. You should make periodic observations.

EXPERIMENT I

1. Take some pea plant seeds of pure breed which produces only white flowers and yellow, round seeds.
2. Divide them into three sets
3. Sow the first set of seeds in a normal way in your garden This is your control experiment
4. Sow the second set at a place free of weeds, well manured and open Water the young plants once a day.
5. Sow the third set at a shady place infested with weeds and lacking manure. Water the young plants once in two days
6. Let all the plants grow, bear flowers and seeds
7. Record your observations

Now analyse what you have observed. What are the colours of flowers and texture of seeds produced by the different sets of plants? What difference do you find in the overall appearance of these sets of plants?

The colour of the flower and texture of the seed are characters which remain grossly the same. Different conditions have not affected the genotype However, the sizes of the flowers, seeds, leaves and the plant as a whole have changed in different conditions The same genotype, therefore, may produce slightly different phenotypes when subjected to different environmental conditions of food, temperature, light, humidity, etc This is a case of environmental variation However, such variations are not inherited.

EXPERIMENT II

1. Select a few seeds of maize, wheat, gram and pea
2. Select a plot which is free of weeds, well manured and open
3. Sow all the seeds in the selected plot and water regularly
4. Record your observations.

You will find that the growing plants could be grouped into four types: maize, wheat, gram and pea. Each group has its own distinctive characteristics The same is true of man, dog, dove and bull Such differences arise due to different genotypes But what about the individuals within the same species? Brothers and sisters of the same family look different, the pups are different from their parents and also from each other Similarly, we find differences among different varieties of mangoes, wheat, pea and a number of other plants

Variations among different species arise due to a gross difference in genotypes, while variations within a species result from the reshuffling of genes during meiosis and mutation You know that during meiosis, the exchange of parts of chromatids results into genetically altered chromosomes. Thus, genetically, the daughter nuclei are not exactly similar to the parent nuclei. When two such nuclei fuse to produce a zygote, the genetic constitution of the zygote would be different Such a zygote would grow into an individual which bears similarities to parents in gross structure, but differing in some details.

The hereditary variation may also be due to the varying number of chromosomes You know that the number of chromosomes and the total number of genes for a species are always constant If the number of chromosomes changes, either naturally or artificially, the resulting offspring would grossly differ from its parents The following example will explain this

The ancestor of the wheat varieties cultivated now had a chromosomal complement of seven pairs. The present varieties of wheat have 14 and 21 pairs. This means that doubling or tripling of the chromosomal number has given rise to different varieties of wheat This is true with many other plants Such a phenomenon is little known among animals

Another type of chromosomal alteration is also known. The chromosomal complement of man, for example, is 23 pairs. If there is an increase or decrease in the number of chromosomes of any one of these pairs, the phenotype is altered considerably and is distinct from its parents In *Datura* (a poisonous plant), the chromosomal complement is 12 pairs But often in several forms of *Datura*, the chromosome number is found to be increased Such plants with changed chromosomal complement bear different phenotypic expression.

Hereditary variations are also caused by mutation of genes, that is, an abrupt change in the gene itself. Hereditary disorders like colour blindness, albinism, and haemophilia are due to gene mutations. The gene responsible for the production of pigments in the skin suddenly changes its behaviour and the pigment production is stopped, resulting in an all white individual known as albino Other abnormalities mentioned also arise in the same manner. Such mutations are permanent and hence inherited

You have already learnt about genes as the basic unit of inheritance An Austrian priest, Gregor Mendel, was the first to assume certain 'factors' as the carriers of individual characters from one generation to another in all living organisms These 'factors' were identified as 'genes' by the later scientists. On the basis of *hybridization experiments*, Mendel developed certain laws of inheritance which formed the basis of the later advances in 'genetics' and 'breeding'. Besides these laws, Mendel's methodology was also used extensively by later workers in this field.

Gregor Mendel worked in his monastery garden at Brunn, Austria (Europe). He was interested in the transmission of characters in plants.

He selected pea (*Pisum sativum L.*) for his experiments for the following reasons:

1. The plants possessed a number of pairs of contrasting characters, for example, red vs. white flowers; round vs wrinkled seeds; etc.
2. It was easy to pollinate the plants of a particular character with the plants of a contrasting character and obtain a fertile hybrid.
3. The pea plants are natural self-pollinating

plants and, after a particular crossing, several subsequent generations could be raised with no incidence of undesirable crossing

Mendel's methodology involved the following : (1) Obtaining seeds which were true to their types, that is, the plants with red flowers always produced generations of red flower plant; (2) counting all seeds and grouping them on the basis of the characters that they represent. His method thus was quantitative and he kept the track of characters of plants of several generations after a particular cross, and (3) drawing generalisations on the basis of the numerical relationships between the hybrids having contrasting characters

He first studied the inheritance of a single pair of characters and later took combinations of pairs of two or more characters His methodology contributed a great deal to his success and still serves as a classic example of scientific methodology

MONOHYBRID CROSS

The monohybrid cross refers to the hybridization experiments involving a single pair of contrasting characters Mendel selected two sets of pea plants One set consisted of tall plants (200 cm and above in height) and the other of short plants (upto 50 cm in height) He first made it certain that seeds from tall plants invariably produced tall plants and the dwarfs produced only the dwarfs in successive generations, that is, they were true to their types or true breeding He then cross-fertilised the tall plants(P) with dwarf plants (P) (P in the parenthesis denotes parental generations) In order to achieve this he removed the stamens at an early bud stage and dusted the pollen of a dwarf plant over the stigma of the tall plants He also made 'reciprocal crosses' so that each set had a chance to set as male or a female parent He collected all seeds upon ripening and raised the 'hybrids' from these seeds He referred to this generation as F_1 or the first filial generation You will be surprised to know that all plants of this generation were tall He then raised the next generation of plants with seeds collected from the F_1 generation after crossing the individuals of this generation between themselves You would probably think that this generation (F_2) would also consist of tall plants only But Mendel noted that this F_2 generation of plants instead of consisting of only tall plants, had 75 per cent tall plants and 25 per cent dwarf plants, that is, a ratio of 3·1 was observed. It was found that the dwarf of F_2 generation when self-pollinated were true breeding, while of the tall plants only 25 per cent were true breeding The remaining 50 per cent of the tall plants, in the next generation, produced tall and short plants in a ratio of 3·1 His plan of work is presented in Fig 18 1

Mendel explained his results in the following way. He suggested that each parent contributed a 'factor' to the offspring. This factor was later termed as *gene* The F_1 hybrids were all tall because the factor contributed by the tall parent was dominant over the factor of dwarfness. He suggested that though both the characters were present in the F_1, the dwarf character remained unexpressed as it was masked by the character for tallness. In the F_2 generation, however, the characters segregated and produced tall and dwarf plants On the basis of these observations, Mendel postulated the 'law of segregation', which stated that the pairs of contrasting character of a hybrid separate from each other in subsequent generations.

It is important for you to familiarise yourself with certain terms which find place in the literature of genetics and their origin can be linked to Mendel's work A pair of contrasting character is observed due to the presence of two *alleles* of a gene which govern the expression of that character A true breeding individual

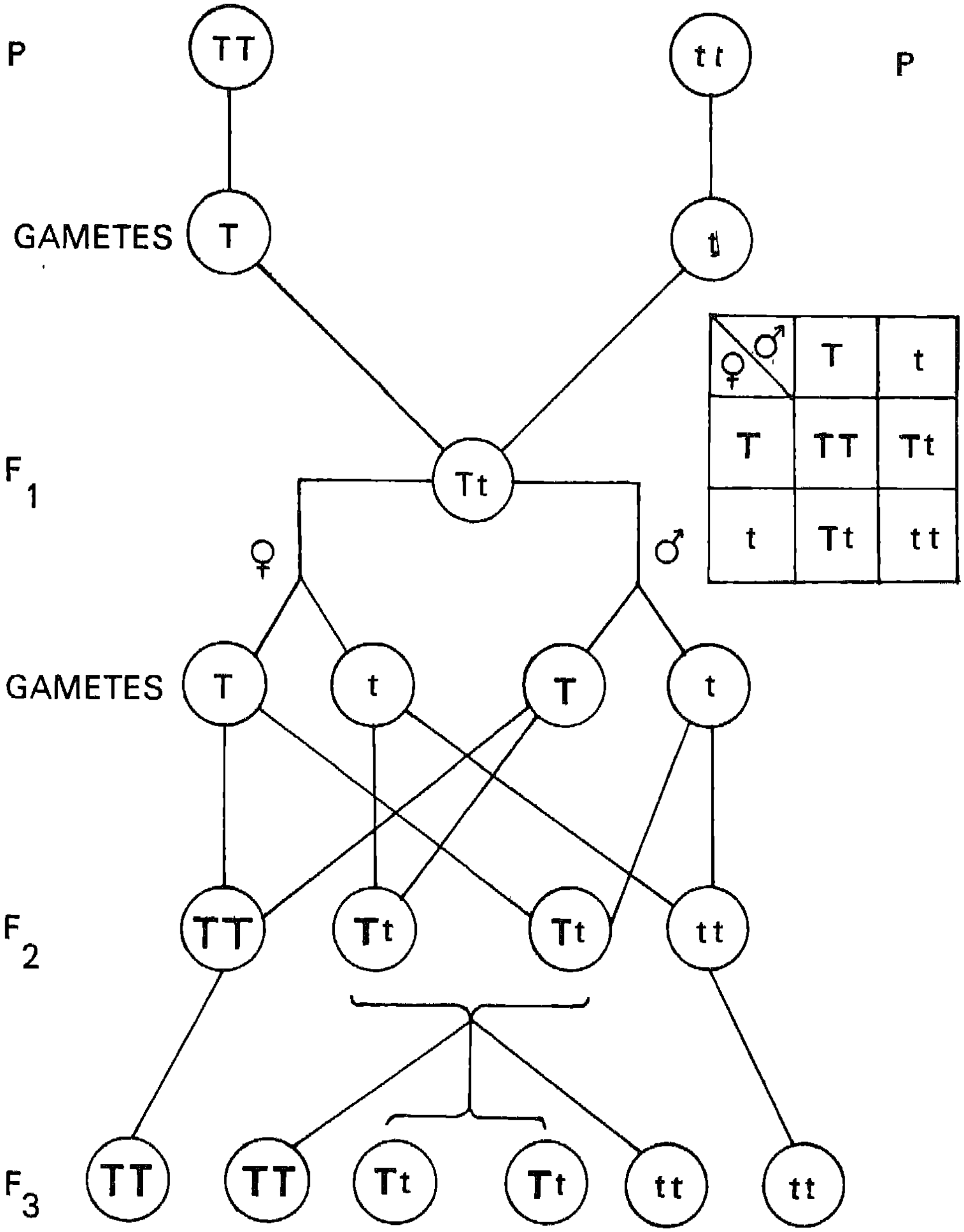


Fig 18 1 Mendel's Monohybrid cross

has identical alleles. for example. a true breeding tall pea plant has alleles for tallness only (TT) while a true breeding dwarf has alleles only for dwarfness (tt) (Fig. 18 1). Such a true breeding individual is *homozygous*, in contrast to a hybrid. which has two different alleles for a particular character Such an individual is referred to as *heterozygous* (Tt) The *phenotype* refers to the external appearance of an individual, for example, Mendel's F_1 plants were phenotypically tall The internal genetic constitution of an individual is referred to as *genotype*, for example, the heterzygote (F_1) had the genotype of Tt and was genotypically different though phenotypically similar to the homozygote TT In genetic terminology, allele 'T' for tallness is known as *dominant* over the allele 't' for dwarfness which is called *recessive*.

You can now proceed to attempt the modern explanation for Mendel's experiment on the basis of the genetic constitution of the individual plants Fig 18 2 illustrates the crosses.

The two parents were true breeding tall and short plants and each formed single type of gametes. The gametes each from either of the parents fused to form the heterozygote of the F_1 generation the plants of which were phenotypically tall but contained the allele of dwarfness as well This heterozygote formed two types of gametes which fertilised each other to form the plants of the F_2 generations which were either tall or dwarf in a phenotypic ratio of 3 1 (tall : dwarf) Genotypically, half of these plants were tall and dwarf homozygotes while the rest were heterozygotes like the F_1

DIHYBRID CROSS

After the study of a single pair of contrasting characters, Mendel started to work on pea plants with two or more pairs of contrasting characters A cross between two sets of plants involving two pairs of true breeding contrasting characters is referred to as a *dihybrid cross*

For this cross Mendel selected a set of plants which were true breeding for yellow and round seeds and another set which always produced wrinkled and green seeds In the F_1 generation of the cross, he observed that all the plants produced only yellow and round seeds. You would expect this on the basis of the dominance of the characters which you have already studied above What did it mean? Which characters were dominant and which were recessive? The F_2 generation of these plants produced four phenotypes of seeds. (1) round and yellow; (2) round and green, (3) wrinkled and yellow

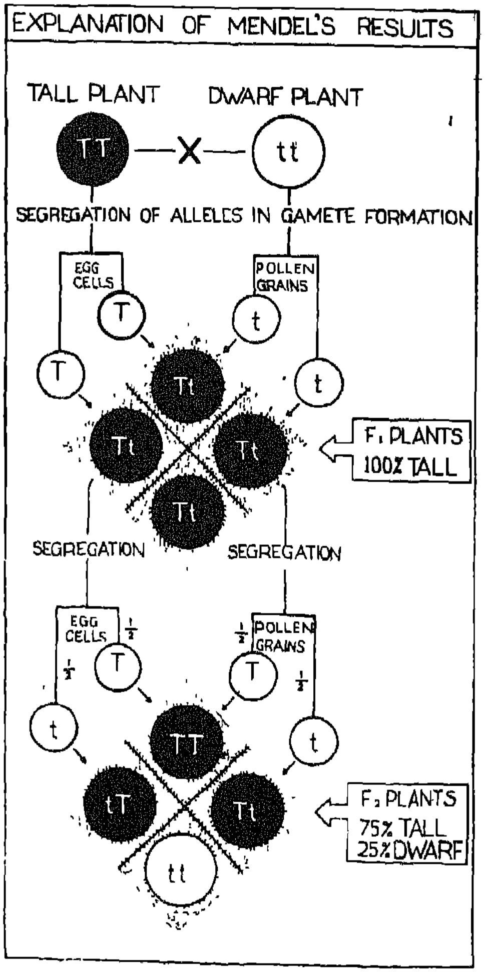


Fig 18.2 Explanation of Mendel's results

and (4) wrinkled and green The ratio between different phenotypes was in the respective order of 9 3:3·1 In order to account for the behaviour in the F_2 generation, Mendel suggested that when two pairs of contrasting characters come from the same parent they may not necessarily stay together but behave as if each character is an independent unit This laid the foundation for Mendel's second law of 'independent assortment' which states that when two pairs of characters are contributed by the same parent in a cross, they assort independently of each other in future generations as independent factors.

On the basis of the genetic diagram of the monohybrid cross, try to prepare a diagrammatic account of the dihybrid cross with the help of your teacher

All these significant experiments of Mendel though performed in the middle of the last century, remained unknown till the beginning of this century After their rediscovery, the significance of these studies were realised and experimentation followed on a large scale throughout the world. Mendel's work and his laws formed the basis of the concept of genes The gene, as you know, is the focal point of the science of genetics. The researches in genetics have led to several improved varieties of crops and animals They have also helped us in understanding the causes of several serious diseases

TEST ITEMS

1 What is the cause of differences between two species?
2. How are the hereditary variations produced?
3. Why did Mendel select the pea plant for his experiments?
4. What were the methods of Mendel's experiments?
5 Explain the following terms .
   (i) Allele; (ii) Genotype; (iii) Phenotype; (iv) Heterozygote, and
   (v) Homozygote.
6. What is the significance of Mendel's theory?

CHAPTER 19

Basis of Heredity and its Mechanism

1 Genes are made of a chemical substance called deoxyribonucleic acid (DNA)
2 The chemical nature of DNA has been known from the studies of micro-organisms
3 DNA is always a double helical chain, but another nucleic acid RNA is singlestranded.
4 The two chains of DNA remain helically coiled and one chain is complementary to the other
5 During duplication, the two chains of DNA uncoil and each synthesises its counterpart.
6 RNA or ribonucleic acid is responsible for protein synthesis and it works according to the instructions from DNA

IT must be clear to you by now that genes are hereditary units You also know that they are located on chromosomes and are carried along with them during cell division In recent times a large number of biologists and biochemists have taken much interest and have contributed towards the understanding of life at the molecular level. The structure and functions of genes as chemical substances have been worked out in details

A chemical analysis of an organism would reveal its chemical composition. A large number of elements go into its make-up Some of the most common elements are carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur Some of these elements make the various organic molecules like fats, carbohydrates, lipids, amino acids, purines and pyrimidines. Some of these molecules join together to form a complex unit called 'macromolecule'. For example, a large number of amino acids join together by specific chemical bonds to form the giant molecules of proteins Another example of macromolecules is the nucleic acid A nucleic acid molecule is a polymer of nucleotides, each of which is composed of 5-carbon sugar, phosphorus, with a purine or a pyrimidine base Purines and pyrimidines are nitrogen-containing 'orga-

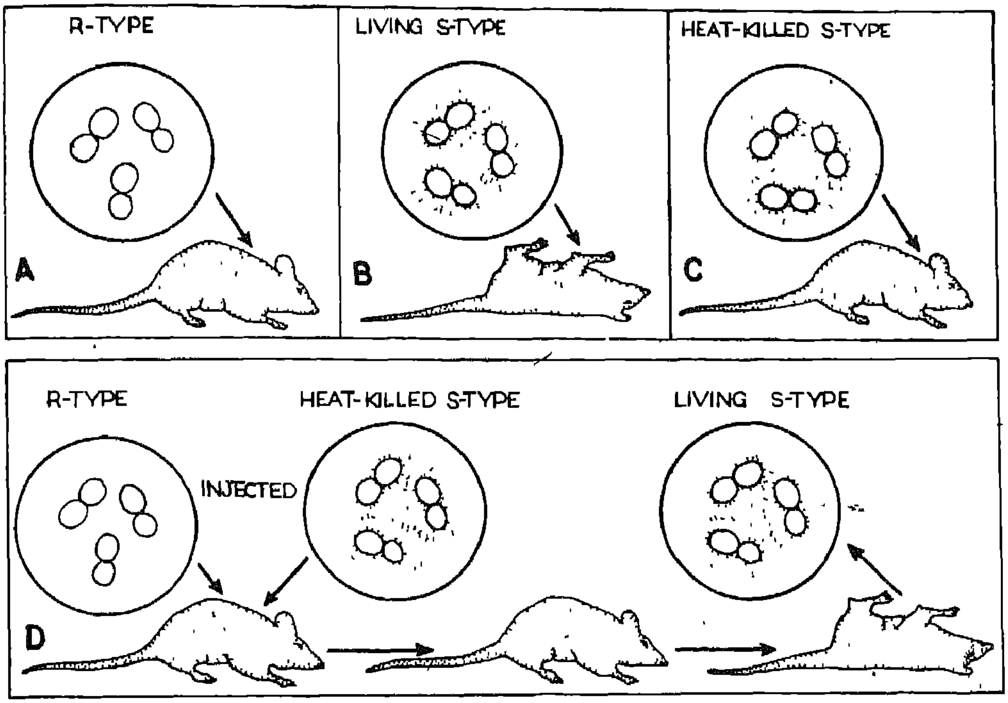


Fig 19 1 The scheme of Griffith's experiment A Harmless R-type bacteria without capsule. B Virulent S-type bacteria with capsule C Heat-killed S-type bacteria did not cause pneumonia D When R-type and heat-killed S-type bacteria were injected together, they produced pneumonia Non-virulent R-type changed into virulent S-type

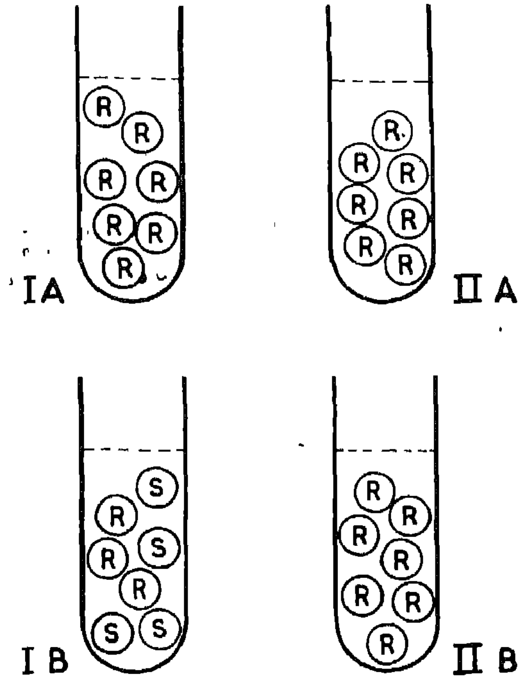


Fig 19 2 The scheme of the experiment performed by Avery, Macleod and McCarty : IA. The non-virulent R-type were cultured in DNA extract from the virulent S-type bacteria. IB The S-type appeared together with the R-type IIA The non-virulent R-type were cultured in DNA extract from the S-type with the enzyme DNAase IIB Only the non-virulent R-type appeared nic molecules On the basis of the type of sugar, whether deoxyribose or ribose, the nucleic acids have been distinguished into deoxyribonucleic acid or DNA and ribonucleic acid or RNA, respectively. The chemical analysis of chromosomes has shown that they are made of proteins and nucleic acids Since it is the chromosome which carries the genes it is necessary to know what part of chromosome carries the hereditary information In order to know the exact nature of genes, whether they are proteins or nucleic acids, several experiments were conducted by renowned scientists. Let us recall some of them.

F Griffith, a British doctor, in 1928 conducted experiments with *Diplococcus pneumoniae*, a bacterium that causes pneumonia This bacterium exists in two different forms known as smooth (S) and rough (R) The S-type of cells have a capsule and are virulent and cause pneumonia. The R-type of cells have no capsule and are non-virulent or harmless When the virulent form (S) was injected into mice, the mice died of pneumonia, but when they were injected with non-virulent form (R), they did not suffer from the disease Griffith killed the virulent type (S) by heat and injected the dead cells into the mice. The mice did not die or suffer from pneumonia. In a second experiment,

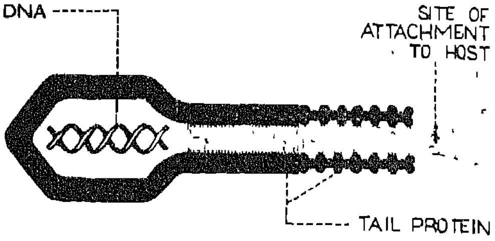


Fig 19 3 The diagrammatic picture of a T 2 virus

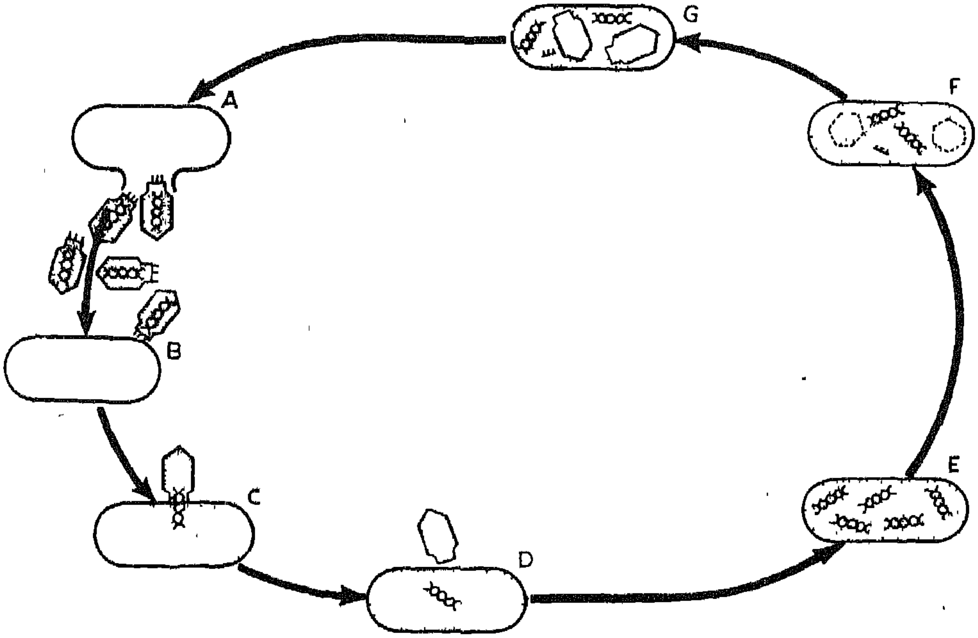


Fig 19 4. Life cycle of a bacteriophage virus inside the bacterium he took the heat-killed, virulent S-type of cells and mixed them with living cells of the non-virulent R-type and injected the mixture into the body of the mice. The mice suffered from pneumonia and died (Fig. 19 1) On examining the dead mice, Griffith found the living cells of virulent (S) strain Obviously, the property of capsule formation was acquired by the non-virulent (R) form, thus making it virulent. This property could have only been transferred from the dead cells of virulent (S) form In a third set of experiments, the scientist took the extract of the heat-killed virulent S-type of cells and mixed it with living non-virulent R type cells. When this mixture was grown in culture, the living virulent, S type of cells appeared Thus, the non-virulent cells underwent transformation.

The significance of Griffith's experiment was realised by O. T. Avery, C. M. Macleod and M. McCarty who in 1944 provided the experimental evidence that the factor responsible for the transformation of the non-virulent type of bacteria was DNA These three scientists isolated the DNA of the virulent (S) type of cells in a purified form. In the first set of experiments, they mixed the non-virulent type of (R) cells with the isolated DNA. In the second set of experiments, they treated DNA with the enzyme deoxyribonuclease before mixing it with the non-virulent type of (R) cells. Both mixtures were grown in culture (Fig. 19 2). They observed that in the culture prepared from the first set of experiments, the living virulent (S) type of cells made their appearance with (R) type of cells. In the culture prepared from the second set of experiments, they could isolate only the non-virulent (R) type of cells and no (S) type of cells appeared. These results concluded that the transformation of the (R) type of cells was due to DNA of the (S) type of cells.

In 1952, A. Hershey and M. Chase conducted experiments with radioactive isotopes and confirmed that it is the DNA and not the

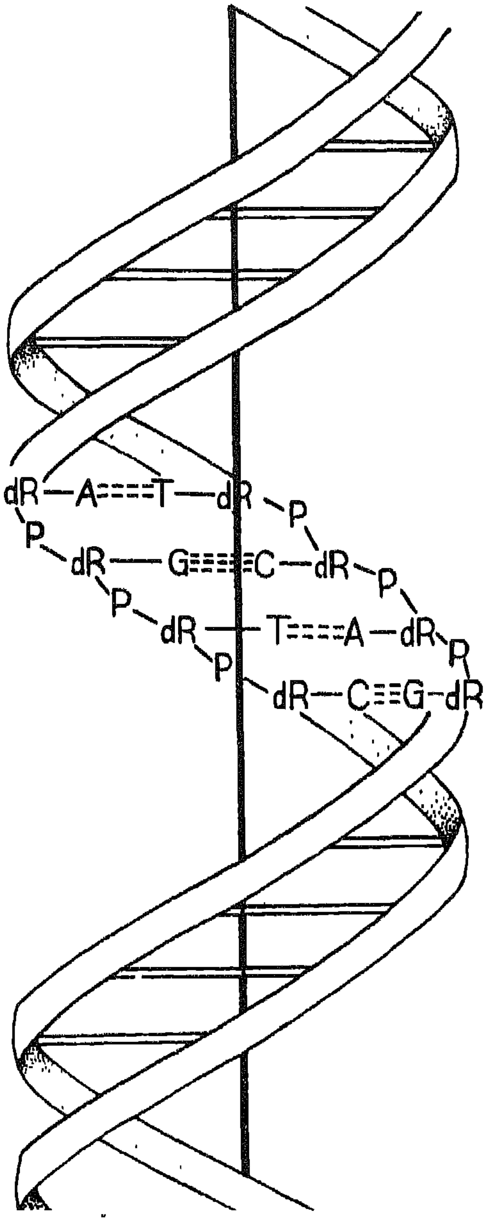


Fig 19 5. Structure of the DNA molecule. Note that adenine binds with thymine and guanine with cytosine.

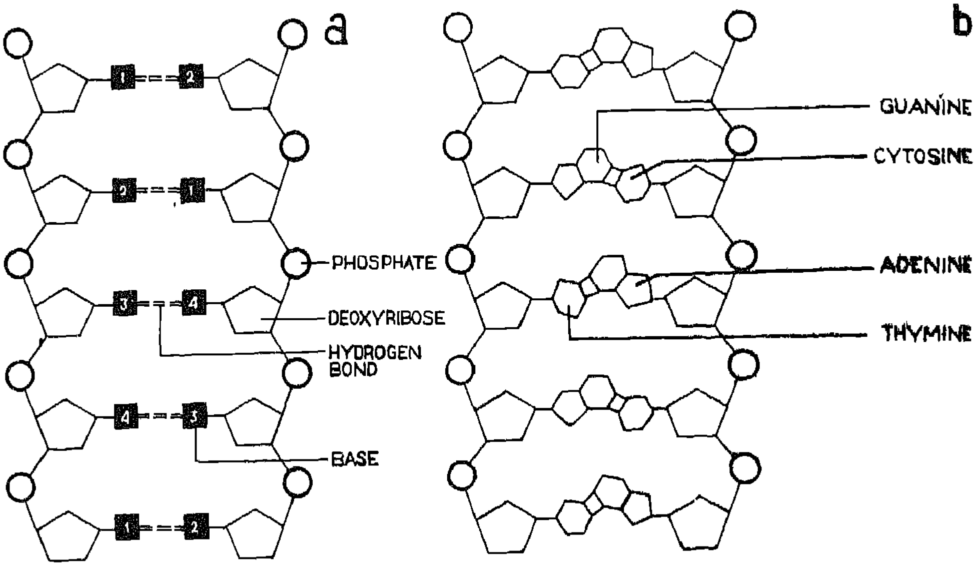


Fig 19 6 Arrangement of the nitrogenous bases in the molecule of DNA. 1-Cytosine, 2-Guanine, 3-Thymine and 4-Adenine

protein which is inherited. They conducted the experiments with *Escherichia coli*, a bacterium that lives in the large intestine of man, and a bacterial virus called T_2 which attacks and kills this bacterium. The virus while attacking the bacterium injects its DNA inside the bacterium (for the structure of the virus, see Fig. 19 3). Thus a large number of virus particles are reproduced which break the bacterial cell wall and become free (Fig 19 4).

We know now for certain that it is the DNA part of a chromosome which is responsible for heredity The second type of nucleic acid, the RNA does not take part in the inheritance of characters The RNA generally is not found in the chromosomes However, the genetic material of some plant and bacterial viruses is RNA. In higher organisms, the RNA is abundantly found in the cytoplasm in special particles called ribosomes and it is also found within the

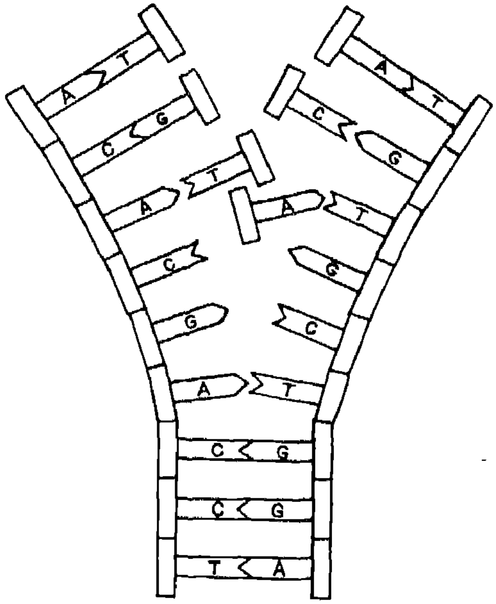


Fig 19 7 Duplication of DNA The two original strands uncoil and each of them acts as the template for a new strand nucleolus In all organisms, the DNA synthesises the RNA to regulate the cell metabolism

CHEMICAL STRUCTURE OF NUCLEIC ACIDS

We have already discussed the various components which form a macromolecule of nucleic acid These molecules are with purine and pyrimidine bases, pentose or 5-carbon sugars and phosphates. A base, a sugar and a phosphate molecules, when join together, form a unit known as a *nucleotide* A large number of such nucleotides join to form a polynucleotide chain known as nucleic acid In the case of RNA, it is a single chain. But in the DNA, it is always a double chain. In this double chain of DNA, the bases of one chain are joined with the bases of the other, forming a ladder-like structure (Fig 19 5) This molecule is further twisted in such a manner that it looks like a double helix (something like a spiral staircase) The type of sugar that is found in the DNA is deoxyribose. The purine bases found in the DNA are adenine and guanine The pyrimidine bases are cytosine and thymine One chain of DNA is complementary to the other An adenine base of a chain always pairs with thymine of the other, while guanine of one strand always makes a pair with cytosine of the other (Fig 19 6)

The RNA differs from the DNA in being a single-stranded chain of polynucleotide and in having the ribose type of sugar instead of the deoxyribose type. The bases are the same except that uracil is present in the place of thymine

REPRODUCTION OF DNA

Just before cell division, the replication of DNA molecules takes place The two strands of the helix separate and each strand builds up its complementary partner (Fig 19 7) In this manner, the two DNA molecules are synthesised which go along with respective chromosomes to the daughter nuclei

How does a DNA molecule control the heredity? How the hereditary information is stored in a chemical compound like DNA? These and other questions will be discussed later.

TEST ITEMS

1 How has it been proved that it is the DNA and not protein which is responsible for carrying the genetic message?
2 How does DNA differ from RNA?
3 What is the composition of a nucleic acid molecule?
4 Describe the experiment done by Griffith in 1928, which required a further study of the chemical nature of DNA
5 Describe the chemical nature of DNA, and draw its structure.
6 How does a DNA molecule duplicate?

CHAPTER 20

Human Genetics

1. Mendel's laws are equally applicable to man.
2 In man, as in other animals, sex is determined immediately after fertilisation.
3 A number of human diseases are due to genetic disorders.
4. There are different Rh factors and blood groups in man. Some of these factors are incompatible and create problems during blood transfusion and pregnancy
5 In the near future, correcting of some of the genetic disorders may become a reality.

MENDEL's theory was first published in 1866, but it escaped the attention of the contemporary scientists Mendelism was rediscovered in 1900 and since then Mendel's law has been found to be applicable to both plants and animals. The growth of genetics was based on the studies of the fruit fly, bread mould, bacteria, wheat and corn All these materials were good for experimental purpose The same was not true for human beings. It was not possible to perform genetical experiments with man This difficulty checked the growth of human genetics. But it was overcome through careful analysis of innumerable family histories. Such studies have contributed substantially to the progress of this branch of genetics. Today, human genetics has proved beyond doubt that Mendel's laws are equally applicable to man as well as to other organisms.

You must have heard about or seen deformed children who are born with minor or major defects. Some of these children die before or immediately after birth. Some continue to live as malformed individuals. Some are born normal but defects appear in them at a much later stage of life In fact a deformed child is added to the human population every thirty seconds.

Man was worried about this problem for a long time But up to the beginning of the twentieth century, he had only superstitions and unscientific explanations to offer for these phenomena. The understanding of the laws of heredity has freed him from such ignorance and reliance on superstitions. Today, man has not only found out the causes of these defects, but also he is in a position to avert some of them. It will not be a surprise if in your generation, you become completely free form the worries and agonies of such dreadful defects. Our understanding of human genetics was possible because of the advancement in the studies of human chromosomes.

HUMAN CHROMOSOMES

You know that the chromosome number in man is 46 Each cell of your body contains 23 pairs of chromosomes (Fig. 20 1) Of these 23 pairs, 22 pairs are similar in males and females Those are called *autosomes* Both the chromosomes of the 23rd pair are similar in females but dissimilar in males In males, one is long and just like those of the 23rd pair in female, but its partner is smaller In both the sexes, the chromosomes of the 23rd pair are called the *sex chromosomes*. They are called XX in female and XY in male

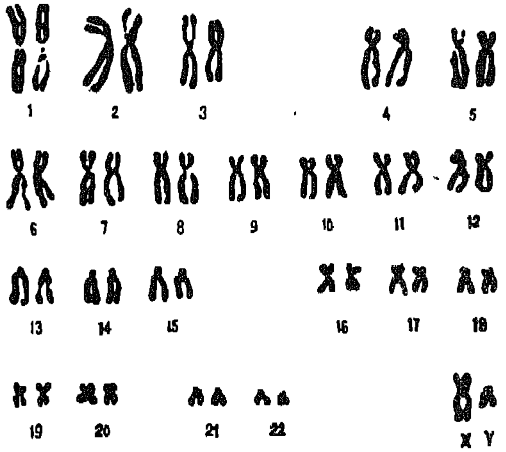


Fig 20 1 The chromosomes of a human male Note that the 23rd pair (without number) has two dissimilar chromosomes, one large (X) and the other small (Y). In human female, however, the 23rd pair is XX

You will be surprised to know that the technique of chromosome study in man was perfected only in the fifties of this century. Today, all the 23 pairs have been properly identified and numbered The improved cytological techniques and a number of specific biochemical tests have enabled us to fight some genetic defects.

The genes which control characters remain linearly arranged on both the autosomes and sex chromosomes Though certain characters are controlled by the action of several genes, it may be said in general, that one character is controlled by one pair of genes, one on each of the chromosome pairs Usually in each pair, one is called *dominant* and the other one remains suppressed and is known as *recessive* In a pair of chromosomes, one is contributed by the father and the other comes from the mother Thus there may be either two dominant genes or one dominant and one recessive genes or two recessive genes In the first two groups the dominant gene will control the phenotype, but in the last category, the characters of the recessive genes will be expressed.

Formerly, it was believed that the sex chromosomes are only for determining the sex (Fig 20 2) Today it is known that there are a number of genes on the sex chromosomes which have nothing to do with the expression of sex. But the transmission of these genes is associated with the distribution of sex chromosomes In female, where two X chromosomes are present, a recessive gene may not be able to express itself, provided both the members of a pair are recessive, but in the male as there is no counterpart in the Y chromosomes, all genes of the X chromosome will find expression. Let us first discuss some disorders which are linked with sex chromosomes

SEX-LINKED DISORDERS

The most common of sex-linked disorders are haemophilia, red-green colour-blindness and a kind of muscular dystrophy. The special feature of sex-linked inheritance will be understood by studying the transmission of haemophilia

The X chromosome in both male and female normally carries a gene which controls the production of a vital factor needed for the quick clotting of blood during bleeding As males have only one X chromosome, this gene can carry out this function. Sometimes, this gene may go wrong and hamper the production of that vital factor. As females have XX chromosomes, the defect in the gene of one chromosome cannot affect the individual. But the female becomes the carrier of the defect (Xx). When she is married to a normal male (XY), the following types of offspring may be produced : Xx, XX, XY, xY. The first category will be carrier female (Xx) but the fourth group will be haemophilic male (xY), second normal female (XX), third normal male (XY). In these males (xY) the chromosome Y does not have the corresponding gene to counteract the defective one on the X chromosome How does a woman become haemophilic ?

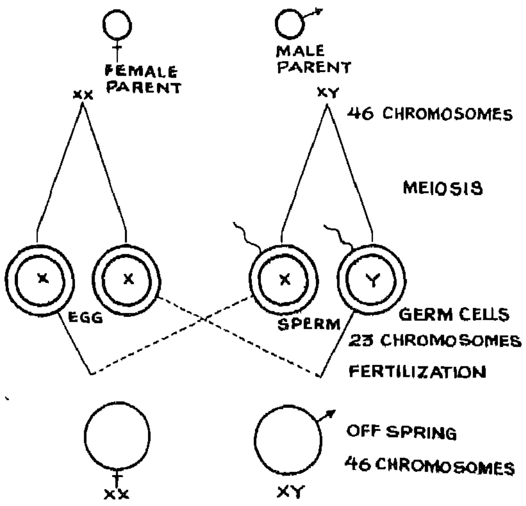


Fig 20 2 Determination of sexes in man

It may be mentioned here that haemophilia, commonly called 'bleeder's disease', has been known to man for a long time. In the haemophilic patient, blood loses the power of clotting Thus any kind of wound will lead to a considerable loss of blood The bleeding may be checked by transfusion of normal blood. All haemophilia cases of today are not due to transmission from the previous generation They may be even due to a mutation or change in the nature of the gene of an individual

AUTOSOME-LINKED DISORDERS

There are innumerable disorders which are transmitted through autosomes. These defects may be either due to some *anomalies of the chromosome or due to incompatibility of genes*.

Anomalies of the Chromosomes. This may happen either due to the *change of chromosome number or wrong exchange of chromosome segments or change in the nature of the gene* It is to be remembered that any change in the chromosome number or morphology will immediately be expressed in the phenotype But changes in the nature of the gene may not be expressed in the individual with the wrong gene Can you guess why ? When do you think that the effects of the wrong gene will be expressed ? A well-known human disorder due to these anomalies is mentioned below.

Mongolism or Down's Syndrome. It was first reported in 1866 The affected child has a very broad forehead, permanently opened mouth, projecting lower lip and a long extending tongue The victim suffers from malformation of the brain and thus has little intelligence. The deformities are also found in the heart and other organs. The real cause of Mongolism was known only in 1959 It was found that all such deformed children posses 47 chromosomes instead of the normal 46. This small extra chromosome carries enough excess genetic material to disrupt the normal development.

It is now known that this extra chromosome comes due to a 'mistake' during the formation of the egg cell The chromosomal studies have now revealed that the mistake is due to the 21st chromosome which fails to separate during meiosis Thus the egg cell which develops into Mongolism contain 24 chromosomes instead of 23. Such defects occur mostly in the ovaries of aged women. That is why most of these abnormal children are born to mothers who are between 40 and 50 years of age

CAUSES AND REMEDIES OF DISORDERS DUE TO CHROMOSOMAL ANOMALIES

Once the reasons of the disorders due to chromosomal anomalies are understood, attempts are in progress to find out the remedies. Considerable information is already available The errors in chromosomal distribution are found to be related to age. Certain environmental factors like the intake of specific drugs and radiation are also believed to be responsible for such defects Between 1957 and 1961, a sleep-inducing drug containing *Thalidomide,* taken by the mothers during the early period of pregnancy (34 to 50th day) was found to be responsible for the birth of deformed children These births are well known in the medical history as the "Thalidomide Babies" It has now been cofirmed that specially during the early phase of pregnancy, the mother, for the interest of her child, should not take any sedatives. Not only thalidomides but several other drugs including antibiotics and LSD (Lysergic acid diethylamide) are also suspected to be responsible for inducing chromosomal disorders Certain viral diseases are also known to be responsible for such genetic errors

Man is fighting hard to find out remedies for these disorders Conscious efforts are going on to minimise various environmental factors which cause the damage and to help the people affected by disorders Technology is brought into prepare artificial limbs and other aids to the deformed. A number of genetic defects, which show their effects through a metabolic deficiency, have been successfully overcome by supplying the body with the deficient substances In genetic defect called, *galactosemia* (inability to utilise the sugar, galactose, in milk), the use of galactose-free milk has given good result

For a long time, blood transfusion was found to be effective in haemophilia Such checking may also be done through the administration of the concentrates of the clotting protein, antihaemophilic globulin.

Today, a number of tests are available to detect the heterozygous individuals with wrong genes. Theoretically, it is possible to graft normal cells so that a new 'factory' is installed to supply the deficient substances in the body.

DISORDERS DUE TO INCOMPATIBILITY OF GENES

You have read about the disorders which are produced by errors of chromosomes or wrong functioning of genes These result in abnormality-bearing persons. But disorders may also be created with the union of absolutely normal individuals Such disorders are very unfortunate

You know that genes in two human beings are not exactly alike. The genes work through the production of chemical substances Therefore, the chemical substances of two individuals are also not exactly alike The disasters come when two individuals, carrying two incompatible chemical substances, unite Of the various chemical substances, two are well known for

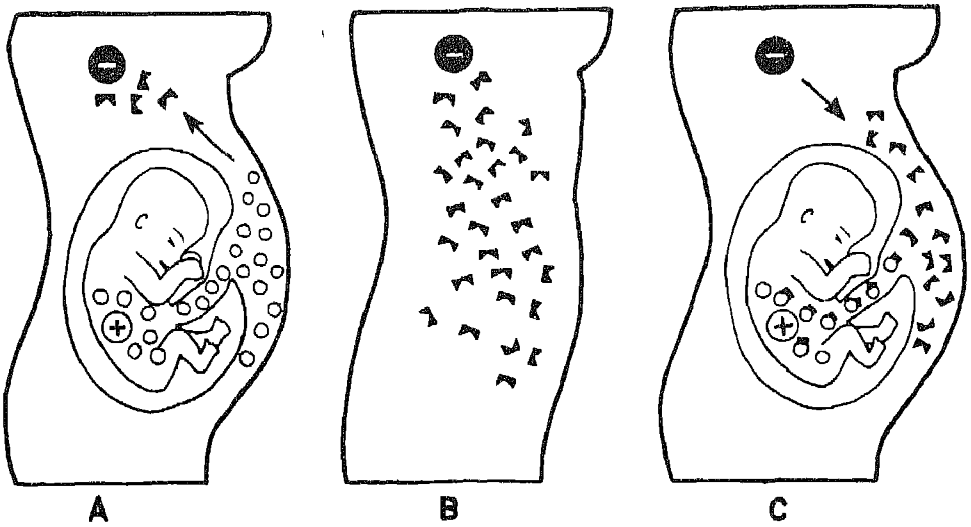


Fig 20 3 Rh incompatibility in man A During the first pregnancy, if the mother is Rh(−) and the foetus is Rh(+) the foetus protein (empty circles) will induce production of anti-factors (black blocks) in the mother B The mother retains the antifactors (though the first child is not affected because of this) C If the foetus of the second pregnancy is Rh(+), the anti-factor in the mother would destory the RBCs of the baby

bringing about such defects; one is the *Rh factor* and the other is *ABO blood group*. Both are present in the blood and are genetically controlled Today, tests are available to find out these chemical incompatibilities Let us discuss what kinds of incompatibility each of these causes.

Rh FACTOR

In the year 1940, it was discovered that the surface of the red blood cell in some individuals (in the U S A, nearly 85 per cent) contains a protein which is also present in the blood of Rhesus monkey (that is why it is called the Rh factor). But 15 per cent of the population does not possess it. The former group is termed as Rh-positive (Rh+) and the later group is called Rh-negative (Rh-).

Genetical studies show that the formation of the Rh protein is controlled by a *dominant* gene, which is termed as R. For this reason, the individuals carrying RR (homozygous) and Rr (heterozygous) will be Rh-positive. Whereas, the Rh-negative individual will have rr (homozygous recessive) genotype Both the positive and negative groups are normal in all respects. But trouble arises when the blood of a Rh-negative individual comes into contact with the blood of Rh-positive individual Such a crisis may occur either during blood transfusion or during pregnancy

If the blood of Rh-negative person was not in earlier contact with the blood of Rh-positive person, then the first blood transfusion will not do any harm The Rh-negative person will grow anti-Rh factor in his own body But if a second transfusion is given from Rh-positive blood, immediately the already grown anti-Rh factors will attack the donor's blood.

But it may be worse, when a Rh-negative woman carries a Rh-positive baby (Fig. 20 3) Either through blood transfusion or through previous pregnancy, if she did not have any previous contact with Rh-positive blood, then her first child will be safe. Only the Rh-positive blood from the foetus will stimulate the production of anti-Rh factor in the mother's blood Enough anti-Rh factor will not be produced during the period of pregnancy, thus the first child will escape the danger. At the time of second pregnancy, if the foetus is again Rh-positive, the anti-Rh factors from the mother's blood will attack the red blood cells of the foetus The child will not only be anaemic but also will show all kinds of developmental abnormalities

ABO FACTORS

In addition to the Rh factor, the surface of the red blood cells of man may contain other types of proteins called A and B According to the presence or absence of these proteins, human beings may be of the following blood groups :

1 *Group A*—Carrying only A and anti-factor for B
2 *Group B*—Carrying only B and anti-factor for A
3 *Group AB*—Carrying both A and B and anti-factor for none.
4 *Group O*—Carrying neither A nor B and anti-factor for both.

These blood groups are controlled by a dominant gene marked L This gene may be of three kinds : L^a, L^b, L^o. One person may have any two of them The genotype of the four blood groups will be as follows

1. Blood group A—L^aL^a or L^aL^o
2. Blood group B—L^aL^a or L^bL^o
3 Blood group AB—L^aL^b
4 Blood group O—L^oL^o

Like the Rh factors, the individuals, of different blood groups are perfectly normal. But the incompatibility of some groups is expressed either during blood transfusion or during pregnancy. Table 20.1 shows some details of the ABO blood groups.

TABLE 20.1

ABO BLOOD GROUPS

Blood Group	*Anti-factor Present*	*May donate blood to*	*May receive blood from*
A	Anti-B	A, AB	A, O
B	Anti-A	B, AB	B, O
AB	Nil	AB	A, B, AB, O
O	Anti-A Anti-B	A,B,AB, O	O

From Table 20 1 you find that group AB can receive from any group but can donate only to its own group. They are called *universal recipients* Similarly, group O individuals are *universal donors* Of course, such terms as universal recipients and donors will depend upon the testing of the Rh factors

The trouble regarding the blood groups arises during pregnancy. The foetus of group B in the body of the mother having group A will be attacked by the anti-factor B of the mother. This will lead to abnormalities, like anaemia, jaundice and other troubles Similar situation arises when other incompatible blood groups appear in the foetus.

PREVENTION OF THE DISORDERS DUE TO INCOMPATIBILITY

The only solution to prevent these disorders is to test blood for Rh factors and blood groups before transfusion and marriage Today definite tests are available for both.

You know that in a number of diseases and surgical operations, it becomes necessary to give blood transfusion to the patient. It is not always possible to get a donor immediately. For this purpose, large hospitals have *blood banks* for storing blood from the donors This blood is carefully stored and is used when required for transfusion. For better storage, techniques have been developed to powder the blood and dissolve it at the time of requirement At each stage, from collection to transfusion, tests are made of both the donors and the recipients, so that the problems due to incompatibility do not arise

TEST ITEMS

1 Why was it not possible to test Mendel's theory on man ?
2 A defect of the gene in a sex chromosome is more easily expressive in males than in females—Why ?
3. A defect of a gene in any autosome may not be expressed so quickly as a defect in sex chromosomes—Why ?
4 What is the cause of Mongolism ?
5. What are the different ways to mend the defects due to chromosomal anomalies ?
6. What is the Rh factor ? When can an individual be Rh-positive ?
7. What happens when a Rh-negative mother bears a Rh-positive child ?
8. Write what you know about blood groups.

CHAPTER **21**

Evolution of Life on Earth

1. Life had emerged on earth approximately 2,000 million years ago
2. The environment which you find today was not the same in the past. It has changed.
3. All living things have also changed. Forms with simple organisation appeared earlier than the complex ones
4. Many living things of the past are now extinct
5. There are evidences which speak of these changes Fossils are the best records of the past life
6. Evolution is a continuous process of change of living forms.
7. The idea of organic evolution is as old as the other theories explaining the origin of life.
8. The names of Lamarck and Darwin are associated with the ideas of organic evolution, because they were the first to come forward with evidences in support of their theories.

WHEN you visit a zoo or when you look at the plants and animals around you, you certainly wonder as to how so many varied forms have originated? You are already aware of the extent of diversity (Fig 2.5) of life forms. How did all these species originate?

When the living forms first appeared on the surface of our planet they were very simple As the years rolled by life became more and more complex till ultimately it culminated in the various forms of today. This is the idea of *organic evolution*. All living forms existing today have evolved from simpler forms which existed on the earth long back In other words, each species, in spite of its stability, is in a state of flux within certain limits and when it transcends these limits it is modified into a new species.

According to the doctrine of organic evolution all the animals and plants which are existing today have descended from simpler pre-existing forms Hence evolution is defined as *descent with modification*

A host of evidences that evolution has actually taken place have now been accumulated A short account of these evidences is given below

EVIDENCES OF EVOLUTION

EVIDENCES FROM PALAEONTOLOGY

The study of past life with the help of fossils is known as *Palaeontology* The geological record is written in the language of fossils which may be the actual remains of the animals buried underground or may be their casts, moulds or impressions The primary and direct evidence in favour of evolution is furnished by fossils The fossils are found in the sedimentary rocks, the lowest strata of which provide fossils of lower animals. In the successive upper strata of sedimentary rocks higher and higher forms of plant and animal fossils are obtained. From these fossils we can learn not only something about the living forms but also about the geological conditions of that period It must be remembered that fossilisation occurs only under ideal conditions. There are two very important conditions for the formation of a fossil The living organisms should have some hard structure, e.g. bones and teeth in the case of vertebrates, shell in molluscs, exo-skeleton in arthropods, etc Secondly, it should be preserved in some protecting medium e g oil-soaked ground, volcanic ash, ice, amber, sand etc

Various methods are now known whereby more or less the exact age of the fossils and the sedimentary rocks can be determined and the entire geological period can then be divided into several *eras*.

Each era is subdivided into *periods* and in turn periods are further divided into several *epochs*.

Although the fossil records are often incomplete, nearly complete sequences of fossils have been discovered in the case of horse, camel, elephant and man. However, the fossils of family equidae are nearly complete and are the most reliable record of evolution The dawn horse—five-toed *Eohippus* of North America and Europe—gave rise to *Mesohippus* which in turn developed into serveral lines of evolution. Finally the modern one-toed *Equus* evolved from *Pliohippus* (Fig 21 1). However, many fossils were discovered which have no resemblance to any of the present day forms and several others exhibited mixed characters of two living groups. The latter type are known as connecting links between two groups. Thus from the study of fossils you may conclude the following ·

1 The surface of the earth has changed in course of time and so also have its living inhabitants
2 Living forms with simple organisation appeared earlier than the complex forms.
3 Several forms bearing intermediate characters indicate transition from an earlier simple to a later complex form
4 Some living forms which were once present failed to survive and thus became extinct

EVIDENCES FROM COMPARATIVE ANATOMY

Various plants and animals carry out certain functions for their existence. These life processes have certain common features and at the same time exhibit certain differences For example, all the chordates like fish, toad, lizard, pigeon and guineapig possess the heart for pumping blood and the brain for controlling different activities If you examine the hearts and the brains of some of these animals (Fig. 21 2), you

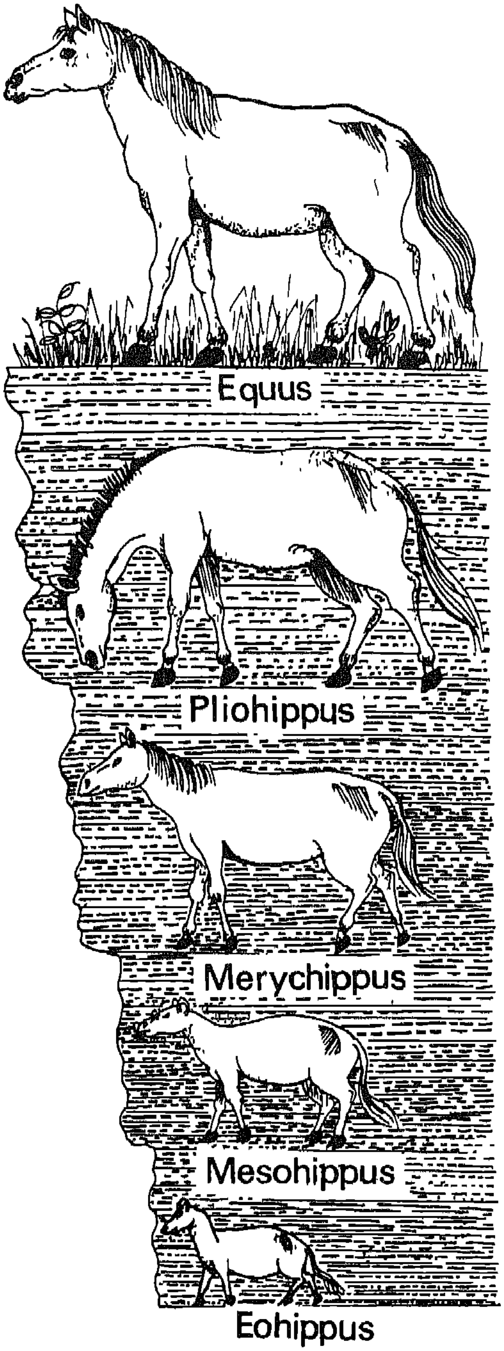


Fig 21.1 Evolution of horse, from *Eohippus* to *Equus*

will find that the organs are simpler in fishes which gradually become more complex in the toad, lizard and guineapig This is true of all other organs. Fossils show that fishes appeared first and were followed by the amphibians, reptiles and mammals The study of comparative anatomy, when combined with fossil evidences, provides a strong support to the idea of organic evolution, animals which originated earlier had a simpler organisation and were followed by complex forms

Homologous Organs. Comparative anatomy provides a number of other evidences. For example, Fig 21 3 shows the forelimbs of different vertebrates. If you look carefully, you will find that there exists a similarity in the basic structural plan but their functions are different. In all of them, the same skeletal elements are present. In all these animals, the forelimbs develop from the same area and follow the same pattern of development. Such organs, having similar origin, may be functionally different. They are called *homologous organs*. The homologous organs speak of a common ancestry of all these diverse forms. Manifestations of this basic pattern have changed in each form according to its specific functions

Vestigeal Organs. In your body there are certain functionless structures (Fig 21 4) called vestigeal organs. Those organs are fully functional in other animals The vestigeal organs are also present in other animals. What is their significance ? Their presence supports the view of organic evolution. It indicates that the organisms with both the vestigeal and functional organs must have evolved from a common ancestor

Evidences from Classification. While studying variation you have noticed that all cats, though dissimilar, have certain common features by

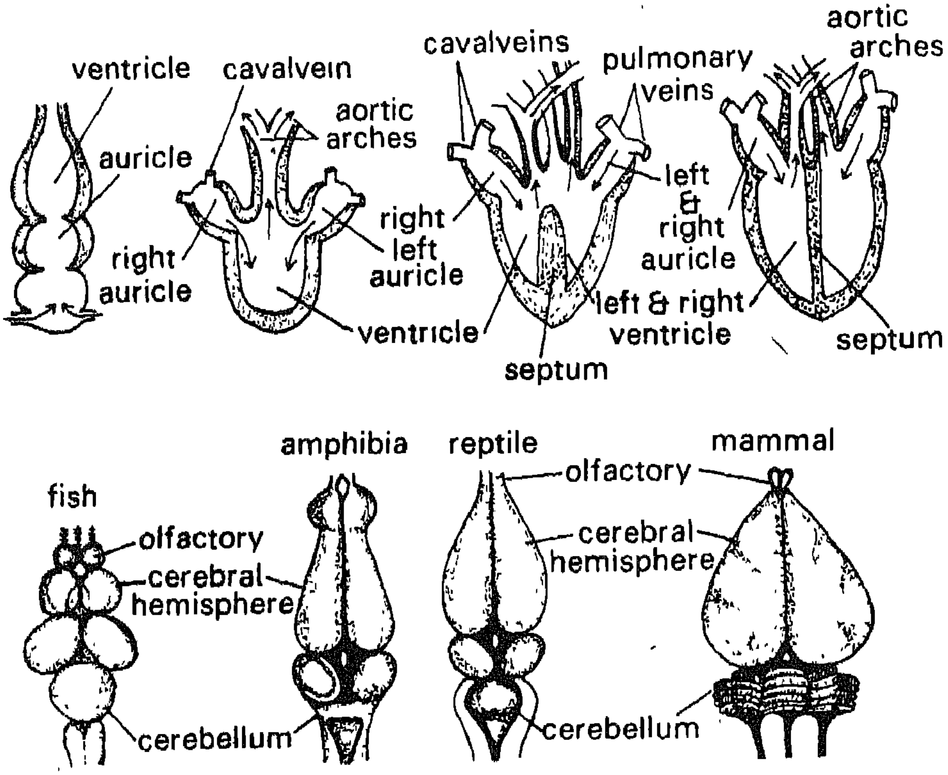


Fig 21 2 A Structure of the heart in different vertebrates. B Structure of the brain in different vertebrates.

which they may be separated from tigers and dogs As regards their characteristic features, cats are closer to tigers, than to dogs Thus, the cats are grouped with the tigers, and the dogs are grouped with the foxes. Cats, tigers, dogs and foxes are closely related. For this reason they are kept in one bigger group, while man and monkey are kept in another

All of the above animals, because of their certain common features, are placed in a wider group which is different from that of birds, reptiles, amphibians and fishes. Such grouping on the basis of actual kinship of organisms forms the basis of *Biological Classification* It provides an important evidence for the idea of evolution, that is, origin from a common ancestor

EVIDENCES FROM PHYSIOLOGY

Like anatomy, physiology also provides certain clear evidences in favour of evolution. For example the physiology of heart, kidney, gonads and of endocrine glands is the same in most of the vertebrates. Hormones and enzymes of all the vertebrates are of similar nature This similarity can only be explained by the common ancestry

The serological test (the study of serums and their actions) provides a very strong support in favour of organic evolution. If human blood serum (fluid part of blood) is injected into rabbit's blood, the antibodies are formed in rabbit's blood against the human serum Thus, the serum of immunised

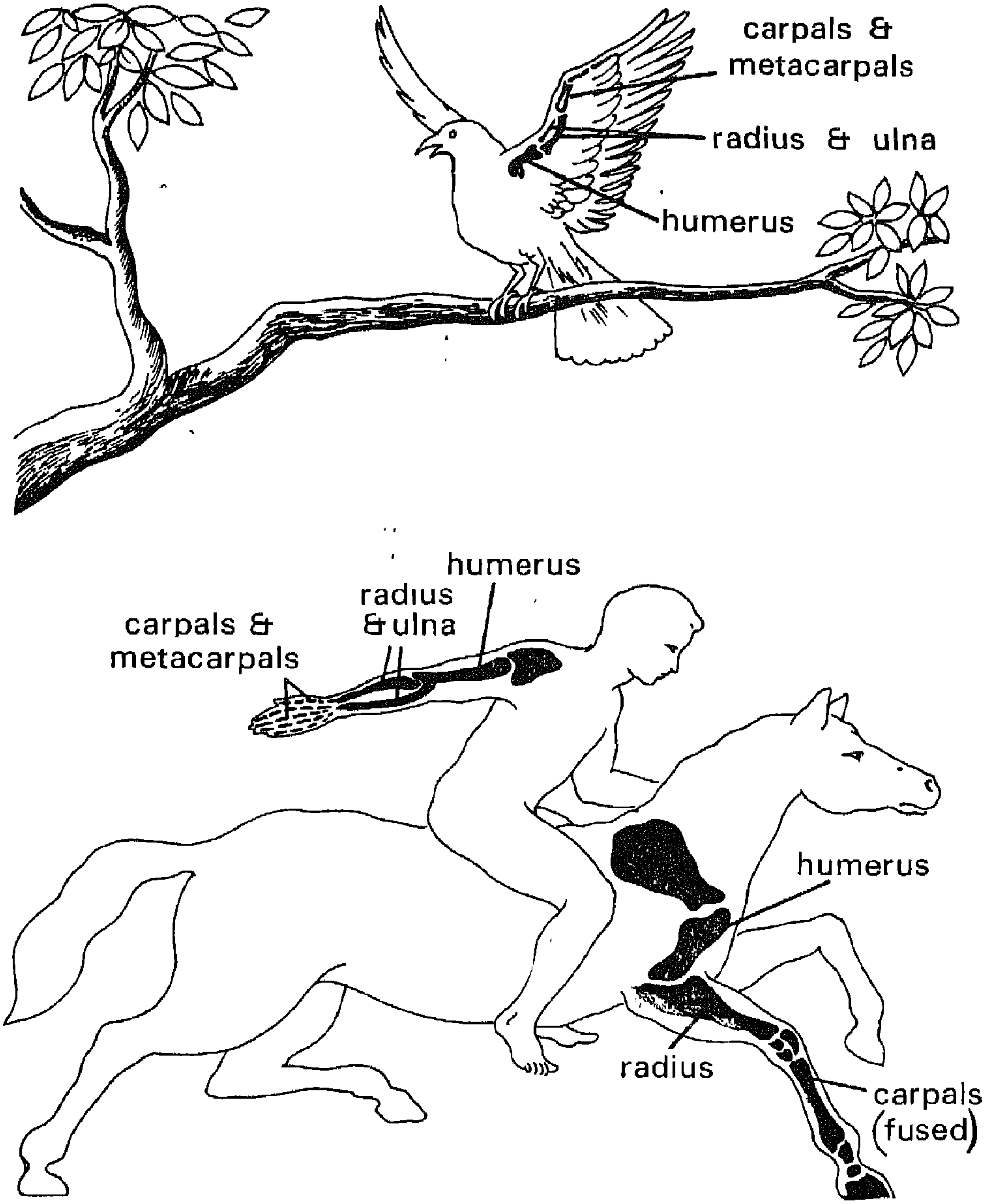


Fig. 21 3 Forelimbs of different vertebrates

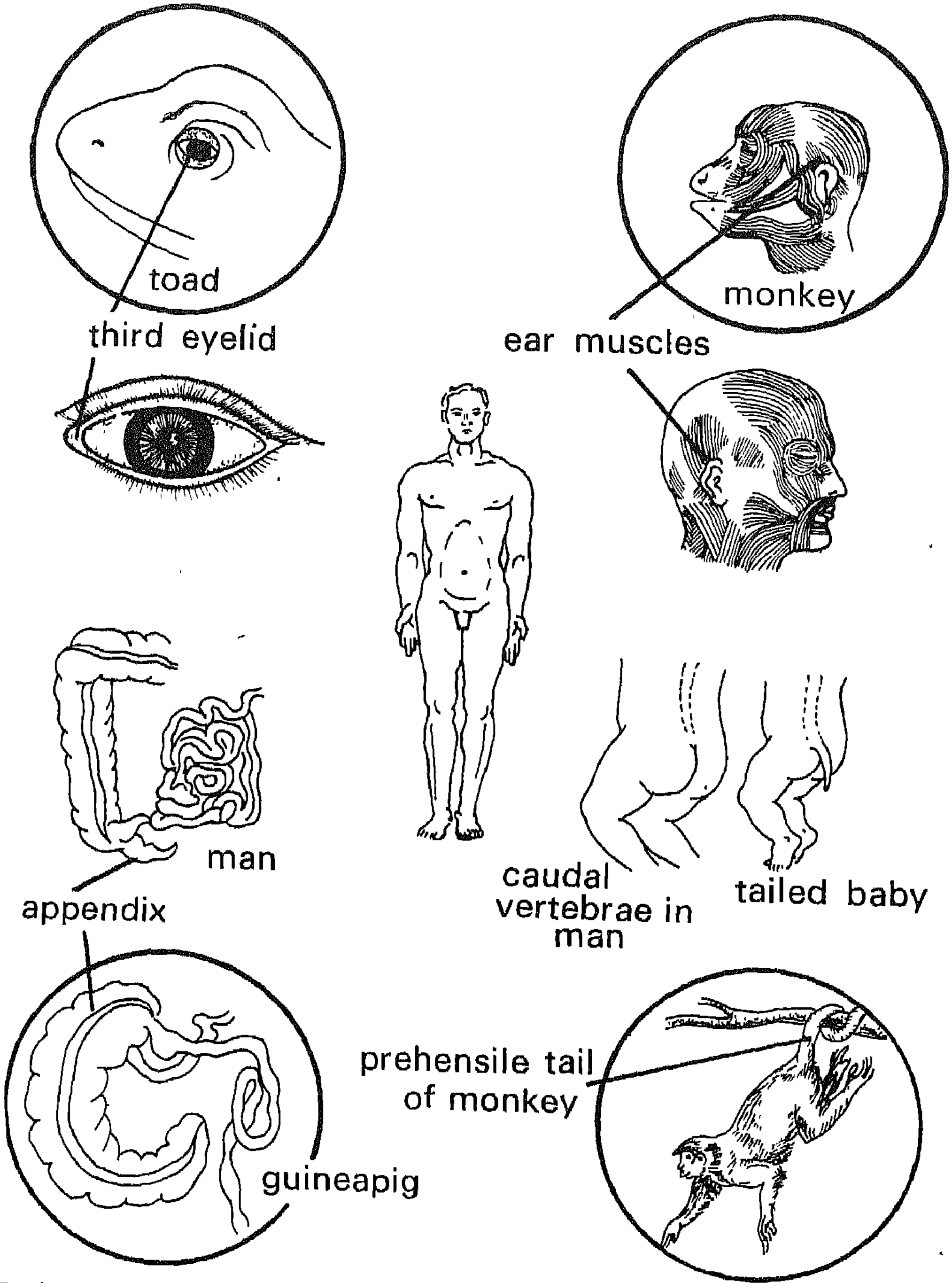


Fig. 21.4. A few organs which are functional in other animals (inside circles) but are vestigeal in man.

rabbit contains antibodies against the human serum. Such an immunised serum is known as antiserum and is used in the precipitation test of serology. Usually such antiserums are very specific and they will react (make the precipitate) against the particular species ; yet the specificity is not complete. It will also precipitate the blood of other closely related species but the quantity of precipitate decreases in distantly related groups, thus when the anti-human serum is mixed with the human blood serum, it is heavily precipitated, if mixed with chimpanzee blood serum, the precipitation is comparatively less, and when mixed with the serum of gorilla, monkey and dog (Fig. 21.5) the precipitation is lesser and lesser depending on the relative distance of relationship with man. Thus, serological tests provide a method of measuring the degree of relationship among widely different groups of animals and is helpful in establishing their affinities.

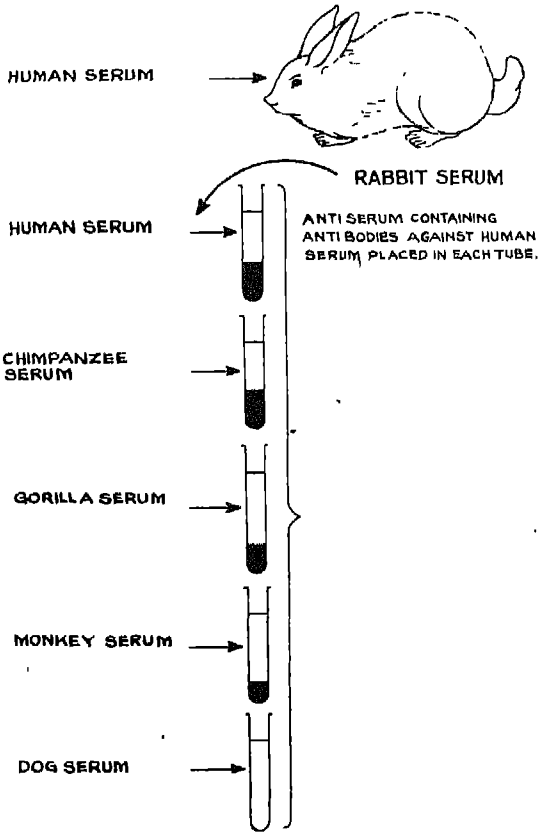


Fig. 21 5 Diagram showing the precipitin test.

EVIDENCES FROM COMPARATIVE EMBRYOLOGY

Except for a few specialised types of reproduction, a multi-cellular animal originates as a zygote or fertilised egg. The zygote of each species has the distinctive ability to produce an individual of that species. But there are many features of embryonic development common to members of any animal group. Therefore, we might anticipate that similar final results would usually be achieved by similar developmental processes. Certain embryonic similarities are shown in Fig. 21.6 which represents several stages in the development of fish, salamander, turtle, chick, rabbit and man Each sequence begins with a single fertilised egg (zygote). To facilitate comparison, the structures of different stages of different animals are drawn about the same size, although they vary in their actual size.

EVIDENCES FROM ZOOGEOGRAPHY

Zoogeography, which is the study of the geographical distribution of animals, is of particular interest and also provides support to the study of organic evolution On the basis of ecological conditions of distribution of animals on the surface of earth six zoogeographical regions have been distinguished.

Every portion of our globe is inhabited by numerous living forms and they seem to be in perfect harmony with their surroundings. However, their distribution is by no means uniform or regular Marsupials are restricted to Australia and South America (with the exception of North American *Opossum*).

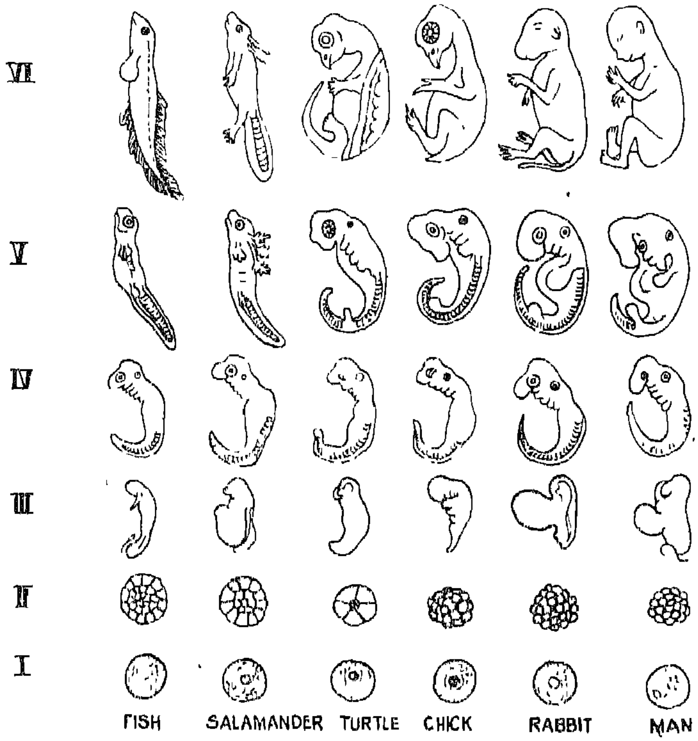


Fig 21 6 Developmental stages of different vertebrates from fish to man Note the similarities of the embryonic stages of various animals

Anthropoid apes occur in isolated areas in West Africa and South East Asia On the other hand, dogs, mice among mammals, thrushes, swallows and plovers among birds and many families of insects are examples of almost universal distribution. Moreover, two countries with almost similar climate and physical conditions contain highly different fauna Thus, the fauna of West Africa with elephants, antelopes and gorillas are entirely different from those of Brazil with tapirs, sloths and monkeys having prehensile tails Distances also do not determine distribution Great Britain and Japan separated by long distance possess similar fauna while the islands of Bali and Lombock separated by only a sea of 15 miles distance contain entirely different fauna

All the above anomalies can be explained on the basis of organic evolution. The present distribution of animals is intelligible only on the following assumptions.

1 Each species has originated only once They originate in all habitats at all times.
2. Each species tends to expand from its centre of origin and this migration is blocked by physical or climatic barriers
3. New species can arise only in isolation and hence related species tend to be found in adjacent areas

EVIDENCES FROM BIOCHEMISTRY AND METABOLISM

The modern chemical study of animal has also provided strong support to the idea of organic evolution Animals of different species may differ morphologically in their structure, but they are almost identical in their chemical make-up

Carbohydrates, fats and proteins are used by the body as fuel to provide energy for all phases of metabolism. The mechanism of energy production and storage is nearly the same throughout the animal kingdom. The universal energy carrier, ATP (adenosine triphosphate), is synthesised by the process of phosphorylation in the cell with the help of mitochondria.

These fundamental similarities can only be explained by the idea of organic evolution, i.e. all these animals have evolved from a common ancestor.

EVIDENCES FROM CYTOLOGY

The fundamental structure of a cell is similar throughout the animal kingdom Why this is so ?

Not only this, but the processes by which cell divides (mitosis and meiosis) are also same throughout the animal kingdom The only explanation is that all the animals had a common origin.

EVIDENCES FROM GENETICS

Genetical studies give strong support to the theory of organic evolution Long ago, Darwin noticed the variations among the individuals of the same species. He was, however, unable to explain the source of variations but now the science of genetics has explained the phenomenon on the basis of mutation and recombination of genes. This new technique has been successfully utilised in hybridization and domestication of animals and plants Geneticists have produced, by proper selection and controlled mating, a good number of hybrids For example, the mule is the offspring from a cross between an ass (*Equus asinus*) and a mare (*Equus cabalus*) This animal is very strong and hardy but sterile.

Some new varieties of chicken, dog, cattle and horse have been evolved artificially which breed true so long as interbreeding with other varieties is prevented

THEORIES OF ORGANIC EVOLUTION

You have already learnt that the idea of organic evolution is quite old Numerous theories have been put forward to explain organic evolution. Of these, the theories put forward by Lamarck and Darwin were based on a variety of evidences. Charles Darwin for the first time gave proper explanations of organic evolution on the basis of a large number of evidences. The works of Charles Darwin not only established the idea of organic evolution but also steered the human thoughts into a different direction.

LAMARCKISM

The idea that living organisms are subject to constant change in structure and habit was first developed by a French biologist, Jean Lamarck (1744-1829) in his book *Philosophie Zoologique*. His conclusions were as follows

1. Life, by its own forces, tends continually to increase it, and to extend the dimensions of its parts, upto a limit which it brings about itself (There is gradual increase in size.)
2. The production of a new organ in an animal body results from the arisal and continuance of a new need, and from the new movement which, this need brings to being and sustains (New need produces new organ)
3. The degree of development of organs and their forces of action are always proportional to the use made of these organs. (Use brings about development and disuse reduction of organs)

4. All that has been acquired, imprinted or changed in the organisation of the individual during the course of its life is preserved by generation and transmitted to the new individuals that descend from the individual so modified. (Acquired characters are inherited.)

When analysed, the first two hypotheses display a markedly vitalistic outlook. Increase of body size and the production of a new organ at will have been adversely criticised and the concepts rejected. The third hypothesis of use and disuse of organs is tenable but it does not form a principle of evolution except in conjunction with fourth law of inheritance of acquired characters. Lamarck assumed that any animal could pass on to its offspring the characteristics it had gained or acquired during its life time. Thus, the offspring would inherit those characteristics which had become enlarged from use or which had grown smaller from disuse. Lamarck used many examples from nature to illustrate his hypotheses. The disappearance of limbs in snakes which crawl on the ground, the appearance of webs on the feet of ducks and geese for swimming, the development of long neck in giraffe to browse upon trees are illustrations in question. In the last century, in spite of many efforts to prove its truth no solid evidence in favour of this hypothesis has been put forward. Weismann's experiments of cutting the tails of mice which never produced tailless progeny gave a serious set back to the theory of inheritance of acquired characteristics. However, it is worthwhile to mention here that Lamarck's insistence on function as the driving force of evolution has probably been the reason why his theory has always appealed more to the physiologists.

DARWINISM

Charles Darwin (1809-1882), the great evolutionist of all times (Fig. 21.7), went on voyage on the ship H.M.S *Beagle* (1831-36) and collected large amount of data which convinced him that evolution had occurred. The evidence consisted of (1) succession of fossils to be found in sedimentary rocks, (2) replacement of living forms of closely related species as the nature of habitat changed, and (3) the distribution of animals (finches) and plants in the Galapagos islands. Soon after his return Darwin read the work of Malthus on the principles of population and was greatly impressed by the alarming potential speed of multiplication of the human race. Another evolutionist Alfred Russel Wallace (Fig. 21 8), a contemporary of Darwin, also came to the same conclusion independently. In substance the theory of Darwin can be summarised as follows :

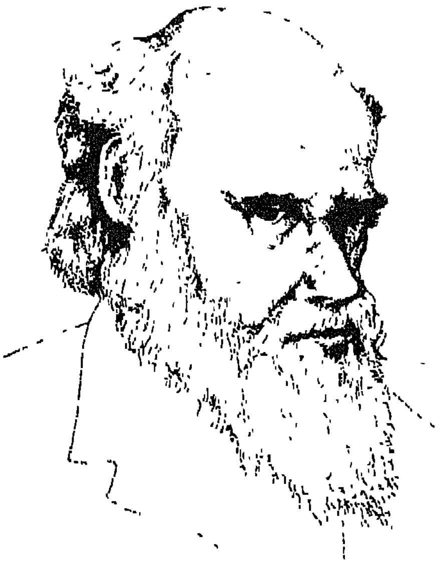


Fig. 21.7. Charles Robert Darwin

1. He accepted from Malthus the fact that the reproductive powers of animals are much greater than necessary to maintain their numbers. Only if a very large population of the offspring are destroyed will the members remain constant as they normally do

2 If a large number of individuals are being destroyed there must be a struggle for existence both between the members of the species and also between species, i.e. the struggle for existence will be both intra-and inter-specific.

3 Animals vary and so he assumed that their variations are inherited.

4. In the struggle for existence, the favourable variations will survive and the unfavourable ones will be exterminated. The favourable variations will accumulate, and this natural selection will lead to gradual change in the characters of species towards better adaptation. This gradual change when it has proceeded enough will result in the origin of new species.

Darwin made two outstanding contributions to evolutionary thought. The first of these was his establishment of evolution as a process. He was able to present enough convincing data that evolution had indeed occurred. His second contribution was his identification of natural selection as an important factor in adaptation and the origin of species.

The period between 1859 and 1900 was a time of rapid development in biology. Mendel's work was published in 1866, chromosomes and their behaviour in mitosis and meiosis were discovered between 1866 and 1885, and rapid progress was evident in virtually every area of biology. In 1900, Mendel's work was rediscovered and fundamental principles of genetics were clarified With the enormous amount of knowledge gained it became obvious that many of the views expressed by Darwin were unfounded For instance, his belief in blending inheritance (characteristics of the parent merged together in the descendants, thus losing their original identity) has been shown to be wrong; his acceptance of Lamarckian inheritance as playing some part in evolution has not been confirmed.

The Darwinian theory of evolution in the form accepted by the biologists of the 1900 had more than one weak side Subsequent work in later years clarified and strengthened his viewpoints and brought about universal acceptance of the theory of natural selection as a guiding force in evolution.

Fig 21 8 Alfred Russel Wallace, who independently reached the same conclusion as that of Darwin.

The development of evolutionary concept in the post-Darwinian period of the early 20th century with the central theme of natural selection has been known as Neo-Darwinism.

TEST ITEMS

1 Name the areas of human knowledge from which the evidences for organic evolution were collected
2. What do you deduce from the fossil evidences ?
3. What do you deduce from the evidences of comparative anatomy ?
4. What are homologous organs ? What is their significance ? Name a few vestigeal organs in the human body.
5 Embryos of all vertebrates look alike in their early stages of development. What does it signify ?
6. What are the evidences against Lamarck's theory ?
7 Discuss Darwin's theory of Natural Selection.
8. Show the differences between Lamarckism and Darwinism

CHAPTER 22

Evolution of Man

1. Man was the last to appear in the long line of organic evolution.
2. Man has evolved rapidly within a short period
3. The success of man is primarily due to the following structural changes: upright posture, large size of the brain, binocular vision and grasping hand
4. Man is the only animal who has established a culture which is also changing.
5. Today the evolution of man is operating at the cultural level and changes are taking place rapidly.
6. Man is the only animal capable of utilising the experience of previous generations
7. The survival of man as well as the survival of other living organisms depend largely on man himself

MAN is the crowning achievement of evolutionary history He surpasses all other animals in mental development, a phenomenon unique in the history of life on earth and which has made him the ruler of the world and the arbiter of his destiny It is, therefore, natural that enquiry into his ancestry has attracted the attention of scientists throughout the world Useful information has been obtained from the fossils discovered in the Siwalik Hills, the Himalayan Ranges in the Punjab In recent years stone age cultures have been discovered in many parts of India A most recent and spectacular find is the discovery of hundreds of caves near Bhopal in some of which stone implements and wall paintings of the primitive man have been found. However, a more correct picture of the ancestry of man has now emerged from a large number of fossils discovered in Africa On the basis of these findings, a reasonably good estimate about the age of man and the various connecting links in the evolution of man can be made.

That man has evolved from some ancestral anthropoids (apes) has been proved on the basis of various evidences from comparative anatomy, embryology, palaeontology, physiology, genetics and distribution of animals. A study of present day animals shows that man shares many characters in common with lemurs, monkeys and apes which are included in the group *Primates*, essentially arboreal, only a few (baboon and man) having returned to a life on the ground There is considerable evidence suggesting that the primitive placentals were tree dwellers to begin with and that the primates have merely continued to follow the ancestral track. Arboreal life is apparently responsible for much of the progressive development of primate characteristics and although man is not a tree dweller, the life of his ancestors has left its mark deeply upon him and is perhaps in great measure responsible for his attainment of the present state The arboreal characters in question are the free mobility of limbs with opposible thumb, stereoscopic vision, simple denition and highly developed brain The nearest relatives of man among the living animals are the anthropoid apes which include *Gorilla* (largest, less arboreal, found in equatorial Africa), *Chimpanzee* (very active climber, found in tropical Africa), *Orangutan* (exclusively arboreal, found in Borneo and Sumatra) and *Gibbon* (small but agile with long arms used as balancers while walking erect, found in Malaysia) However it has been proved that the present apes are too much specialised today to be man's direct ancestors There are evidences to show that both apes and man have been evolving and deviating independently from some primitive common ancestor

AUSTRALOPITHECINES (*PREHOMINIDS*)

Within recent years the important fossil discoveries made in South Africa have shown the remains of some advanced prehominids which lived during the first great ice age (700,000 years ago). The first fossil to come to light, the skull of a baby animal, was named *Australopithecus*. Subsequently, the skulls and portions of skeletons of adults were found not only in South Africa but also in East Africa, Israel, and the Orient and although they were given different names, it seems that they may be included within two genera, *Australopithecus* and *Paranthropus*, each representing a separate line of evolution The *australopithecines* show an interesting mixture of ape and human characters In size these apes were like the pigmy race and they were dwellers of arid regions These apes were of more or less erect posture as is evident from their bone structures. They had broad and flat hip bone (in normal apes it is narrow and elongate), an ankle bone with proximal end broad (for weight lifting-man) and fragile upper limb. The brain capacity was, however, only 600 ml (half that of man) Thus, a creature with brain of an ape and limbs of a man existed in the past. It appears that the perfection of the limbs for erect posture conditioned the elaboration of the brain Can they be included in the group apes? No, because the body structure was very human like though the brain was small Was it then a man? No, because it could not speak nor could it fabricate tools (no stone implements were found with them) Many baboon skeletons found nearby have hip fractures indicating death by blows. *Australopithecus* therefore, had superior intelligence than baboons. All these facts are highly suggestive of their being intermediate between apes and man Even though human beings may not have descended from the *australopithecines*, it is very likely that man arose from *australopithecine*-like ancestors (Fig 22 1)

FACTORS OF HUMAN EVOLUTION

Four factors have been of prime importance in determining the evolutionary development of

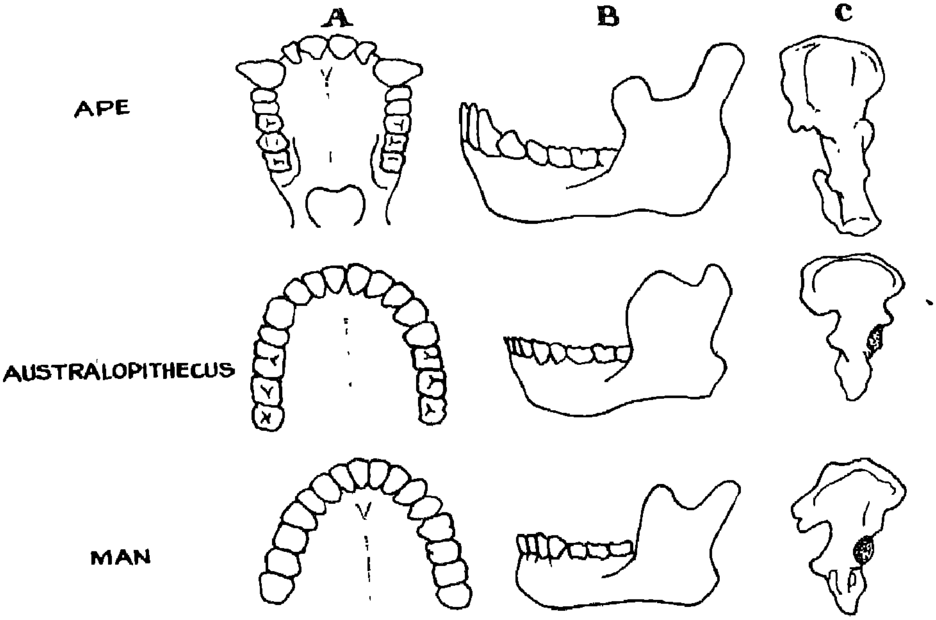


Fig. 22.1. The salient skeletal features of ape, *Australopithecus* and man. A-upper jaw, B-lower jaw and C-pelvis

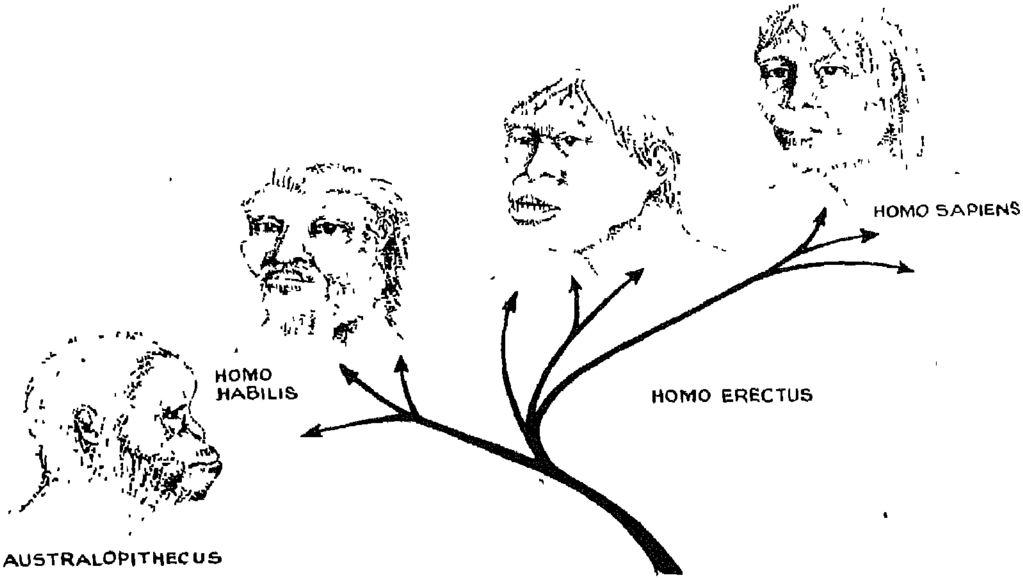


Fig 22 2. Evolutionary tree of man.

man from an ape-like primate The first factor is the growth and elaboration of the brain which resulted in the bulging cranium with a broad forehead. Consequently the face became vertical and jaws short with a parabolic curve instead of U-shaped arch. With the growth and increasing complexity of the brain man became a thinking creature. The growth of intellect resulted in the ability to communicate ideas by facial gestures and especially by speech. He also became a tool-maker and this ability hastened the progress of man by enabling him to adjust to varied environments and in overcoming his enemies The second factor is the development of upright posture which freed the hands completely from the necessity of assisting in locomotion The hands were now available for picking up things and examining them. The erect posture has involved a change in the backbone structure whose vertebrae are aligned in a complex, S-shaped flexture that throws the body and neck into an upright position, with the head balanced on top of the neck With the development of bipedal locomotion, man has evolved long legs and short arms in contrast to those of other primates The third important change in the evolution of man has been the increased period of growing up. Man takes about twenty years to reach to full stature as compared to ten years in the case of gorilla. This longer interval enables the young to remain associated with their parents for a longer period leading to the perfection of family life Finally, the growth of human populations (family, clan, tribe, nation) which has taken place during the last few thousand years, has been responsible for the development of social relationships and making man unique among animals, a being with a culture

PALAEOLITHIC CULTURES

The Pleistocene period has been the evolutionary cradle of man, the *Homo sapiens* This period probably started one million years ago and has seen four glacial periods separated by interglacial periods Though glaciation was restricted to northern continents, it, however, affected the climate of Central Africa which had wet (pluvial) and dry (interpluvial) periods correspondingly From the glaciation it has been possible to date the skeletal remains of man, which of course are very rare. In view of the paucity of this direct evidence, collateral evidence from the stone implements which are discovered in large numbers is sought. The first stone implement appeared in the early Pleistocene and there is good evidence to say that they are not found earlier than this period Throughout the Pleistocene, stone tools were fashioned entirely by chipping This is known as the Palaeolithic Age (Old Stone Age) The art of shaping implements by grinding and polishing was not discovered till later, in what is called the Neolithic Age (New Stone Age) This was followed by the Metal Age The Neolithic and Metal Ages are put in the postglacial or recent period The Palaeolithic Age is divided into a number of cultures according to the manner of chipping and flaking the implements

EARLY HOMINIDS

Now let us look at the fossil evidence of the types of men which were responsible for developing the Palaeolithic industries. The earliest known representative of true man probably lived in East Africa In 1964 a small number of fossils have been found in the same beds as those which contained the fossils of *australopithecines* They have been named as *Homo habilis* and had a cranial capacity of 680 ml They were makers of the crudely chipped stone tools. In the Far East also hominid fossils were found in Java (1906) and in China (1927). The Javanese fossils were designated as *Pithe-*

TABLE 22.1

Geological time	*Glacial sequence*	*Cultural stages*	*Man associated with these cultures*
Recent	Postglacial	Metal Age (1600 years) Neolithic Age (7,000 years)	
		PALAEOLITHIC AGE (1 to 7 cultures)	
	20,000 yrs	7. Magdalenian (polychrome paintings and carved implements)	
Upper Pleistocene	(iv) wurn glaciation (40,000 yrs)	6. Solutrean (javellin blades)	
		5. Aurignacian (bone and horn used, cave drawings)	Cro-magnon man
		4. Mousterian (ceremonial burial)	Neanderthal man
	3rd Inter glacial period (250,000 years)	3. Levalloisian (flaking and chipping done carefully)	Ehringsdorf man
	(iii) Riss glaciation		
Middle Pleistocene	2nd Interglacial period (500,000 yrs)	2. Acheulian (hand axe perfected with cutting edge)	East African man Steinheim man Swanscome man
Lower Pleistocene	(ii) Mindel glaciation 1st Interglacial period (600,000 yrs)		
	(i) Gunz glaciation	1. Abbevillian (crude hand axe)	Heidelberg man China man Java man Habilis man Australopithecus

canthropus, and those from China as *Sinanthropus*, but it is quite evident that these early men were essentially the same and therefore should be placed in single species The modern trend is to include them within the species *Homo erectus*. *Pithecanthropus*, the Java man, had a brain capacity of 850 900 ml (in modern man it is 1350 ml) and could stand erect. He was a short statured creature (1 5 m height) with modern limbs, heavy brows, retreating forehead, powerful jaws and neck muscles with low level of intelligence Implements of quartz found near his remains show that these early men could fabricate tools. Also the presence of numerous hearths is indicative of the fact that they knew the use of fire He was a great hunter (70 per cent of animal bones near his remains are of deer) and most likely practised cannibalism as many of the skulls show signs of injury. Thus, in the lower Pleistocene, a primitive type of man associated with Abbevillian culture was in existence. Of about the same antiquity, a single jaw was discovered in Heidelberg (1907) whose dentition was very human like but it possessed primitive features It was massively built, had no chin and the ascending hind jaw was very wide. No flint implements were found with these fossils This find has been named as Heidelberg man *

In 1935, two bones (parietal and occipital) of human skull were discovered in Swanscombe (Swanscombe man) They are very thick but human-like with the endocranial capacity of 1300 ml They are from the Acheulian phase. From this it is clear that in Europe a man very like *Homo sapiens* existed in the Acheulian period.

In 1933, another skull as old as Swanscombe was discovered at Steinheim (Steinheim man) with prominent eye brows, strongly built upper jaw, the back of skull rounded and brain capacity of 1000 ml In 1928, another skull, probably closer to that of man, was discovered at Ehringsdorf (Ehringsdorf man) with high vault, well developed forehead, rounded occipital region, eye brows strongly built, lower jaw with retreating chin and a brain capacity of 1450 ml This is from the Mousterian phase

Other skulls which probably date from the later part of the last interglacial period have been found in France and Palestine

Recently, a large number of fossil skulls of Acheulian man have been found in East Africa. They possess prominent chins and are almost man like. Probably they hunted mammals as is evident from the hand axes found near them. No signs of fire have been found This rich and antique find throws light on the fact that *Homo sapiens* was in existence at least in Africa in the Acheulian times; probably the Acheulian culture started from Africa and spread to other parts of the globe. More evidence is, however, needed to confirm this.

We can conclude, therefore, that the available fossils can be arranged in a series as *dryopithecine*, *australopithecine*, *Homo habilis*, *H erectus* and *H sapiens*, which form an almost complete and gradual transformation from apelike ancestor to modern man (Fig 22 2). The *australopithecines* were certainly apes which could, of course, walk erect. The difference between the most advanced *australopithecines and H. habilis* was no greater than that between closely related species of animals except that the stone tools probably made by *H. habilis* must have required a greater development of the learning process than that found in any ape. On the other hand, the differences between *H. habilis* and *H. erectus* are in all respects only quantitative and they are not very great Recent interpretation of the fossil records have led to the belief that from the time of *H erectus*, 600,000 years ago to the first appearance of modern man, entire Eurasia and Africa were apparently occupied by a single species of man. Through the ages, this species evolved gradually and from the beginning was subdivided into many races which arose in various places

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* In 1972 Richard Leakey has found remains of skull and leg bones of a man-like creature who probably lived two and a half million years ago in East Africa. His brain capacity was 800 ml and height 1.5m More recently in 1974 he discovered some more fossil remains of the same type of creature but still older in age. These finds will greatly revolutionise our thinking about the ancestry of man More details of these find are awaited

NEANDERTHAL MAN

Mention may however be made of an aberrant form which became widespread in the Mousterian phase. It became known under the name of *Homo neanderthalensis* because its fossils were first found in Neanderthal cave in Germany. Later their remains were found in France, Belgium, Gibralter, Italy, Palestine, Russia, Siberia and North Africa showing their wide geographical range. In contrast with other primitive types of man, the skeleton of Neanderthal man is nearly completely known. This was a race of short statured (about 1.5 m), muscular individuals with barrel-shaped chests and which walked in stooping fashion. Since he was much more ape-like than *Homo sapiens*, it was taken to represent a stage in the evolution of *Homo sapiens*. However, the discovery of human remains of Premousterian date, has cast serious doubts on this conception. In Acheulian times *Homo sapiens* or persons like him were in existence. It is clear, therefore, that the Neanderthal man does not represent an intermediate stage. Rather he was an aberrant side line of evolution. There are other facts which support this conclusion. The possession of taurodont (large pulp cavity) molar teeth, over-developed brow ridges and bent gait are specialised characters peculiar to this group. In their chronological sequence, early Mousterian skulls of the Neanderthal man are less 'Neanderthaloid' than of later date. No fossil remains of the Neanderthal man later than Mousterian have been found showing transition into *H. sapiens*. The brain capacity of this creature was 1450 ml. This large size does not fit into the direct line of evolution of modern man

Men of Neanderthal appearance were not confined to Europe but spread to other parts of the world In Rhodesia the skull and limb bones of these men were discovered in 1921. The skull (1300 ml capacity) was massive and Neanderthaloid but the associated limb bones were human like (*Homo rhodesiensis*). Though Levalloision implements have been found along with the remains, the fossils do not seem to be of great antiquity because the pathological condition of teeth indicated a recent origin. In 1931-32, many skulls of late Pleistocene were found in Java near Solo (*Homo soloensis*) which show resemblance with Rhodesian skull and limb bones. The brain capacity was 1150 to 1300 ml. The Rhodesian and Solo men appeared to be varients of the Neanderthal type.

We can conclude that the Neanderthal man developed from *Homo erectus* and became a highly specialised race which finally became extinct.

At the end of the Mousterian phase of Palaeolithic culture, the Neanderthal inhabitants of Europe were abruptly replaced by people of completely modern European type. This new population, the Aurignacians, probably came from Asia and with their superior social organisation replaced the mousterian man. The Aurignacian remains have been found to Cro-magnon in France. These people were finely built, muscular with high cranial capacity and with refined social features. The Aurignacian culture was followed by Solutrean and Magdalenian which then entered the Neolithic Age, 7,000 years ago.

TEST ITEMS

1 Complete the following sentences.

   (i) The history of man on the earth is——years old.
   (ii) Man, apes and monkeys originated from——mammal.
   (iii) Three important structural changes in the evolution of man are as follows :
      (a)————
      (b)————
      (c)————

2. Name some fossils of man which were found in different parts of the world.
3. What are the special features in the evolution of man ?
4. Why is it said that the future of man and other living organisms depends upto man himself ?

UNIT—5

AGRICULTURAL PRACTICES AND ANIMAL HUSBANDRY

CHAPTER 23

Crops and Factors Influencing Crop Production

1. Agriculture is the largest enterprise in our country and nearly 70% of the population is employed in agriculture.
2. Several factors influence the crop production.
3. Scientific methods have already improved the crop production in our country and there is still more scope for improvements.
4 All persons, including yourself, can take part in the production of crops.

AGRICULTURE in the wider sense is the study of the science and art of production of plants and animals useful to man. Agriculture includes the cultivation of land, and breeding and management of crops and animals. It is derived from the Latin words *Ager* which means field and *Cultura* which means cultivation. Wherever we live, we are dependent on agriculture for our food, clothing and shelter, and for many other things we use in our daily life.

Horticulture, (*Hortus*—Garden, *Cultura*—Cultivation) a branch of agriculture, is the science and art of growing vegetables, fruits and ornamental plants.

Agriculture is still the largest enterprise in our country and nearly 70 per cent of the population is employed in this sector. Agricultural production has to be maximised, to meet the requirements of increasing population in our country. A new strategy of intensive agricultural production based on the application of science has been adopted to make the country self-sufficient in its food requirements. Speedy improvement of agriculture is vital to the progress of our country. The new strategy depends upon making the best use of the soil, water, climatic factors, available resources and on adopting improved agricultural practices. India has achieved significant increases in yields of crop plants. To some extent, increase in crop production has been achieved by bringing more land into cultivation. There is a limit to increase in area as the forest lands and pastures should not be brought into cultivation Therefore, the production from the cultivated lands is being continuously increased by following improved agricultural techniques.

FACTORS CONTROLLING CROP PRODUCTION

The four most important requisites of successful agriculture are : soil, water, air and sunlight.

Climate is the sum total of all environmental factors affecting organisms. Variations in the availability of water, sunlight and temperature mainly constitute the climate of a region. Our soil and climates show distinct regional patterns. Favourable climatic conditions are essential for obtaining good crop yields. Prevailing local weather conditions also influence crop production. India is a vast country. There are wide variations in the climate along the length and breadth of our country The climate ranges from tropical to subtropical to temperate conditions. Excessive rainfall, droughts and floods are a recurring feature and they cause serious losses in foodgrain production in our country.

SOIL

The soil consists of the outer thin layer of the earth's crust. The soil is called the 'Mother Earth'. The constituents of the soil are water; air; organic matter (decaying plant and animal material is known as humus); inorganic matter (mineral matter); living organisms (a) Micro-flora : Bacteria, Actinomycetes, Algae and Fungi (b) Micro-fauna : Protozoa, Nematodes; besides worms, insects of different sizes and kinds.

The texture of the soil may be coarse (sandy), medium (loamy) or fine (clayey). The primary particles of sand silt and clay determine the soil texture The different proportions of these particles constitute different soil textures.

Soil is the natural medium which supports the growth of plants on the earth's surface. Plants are anchored to the soil. Soil serves as the reservoir of nutrients and water for plants Plants are also being cultivated now in solutions containing the required mineral nutrients

The soil texture and the content of organic matter, water and minerals control the physical and chemical properties of soil. With the help of your teacher you may analyse the soil by simple methods to study its physical and chemical properties.

WATER

Plant needs water during its various stages of growth and development. Water requirements of different crops and of the same crop at various developmental stages vary. Lack of sufficient water at germination, tillering, flowering and grain filling stages lead to reduction in the yield or crop failure Crops have to be adequately irrigated, taking into consideration their water requirements.

Out of about 164 million hectares (1973-74) of land under cultivation in our country, only about one fourth of the area is under irrigation. The cultivation in the remaining three-fourths area still depends on rainfall which is largely uncertain.

SUNLIGHT

One of the favourable features of Indian agriculture is the availability of abundant sunlight and favourable temperature throughout the year. This ensures proper growth of the crop throughout the year in several areas, if other facilities are made available Double or multiple crops can be raised in these regions by cultivating early maturing varieties. The following inputs are the most important for agricultural practices and require greater attention.

1. Use of the improved varieties of crop plants and improved cultivation practices.
2. Application of proper manures and fertilisers
3. Adequate and timely plant protection measures.

4. Adequate and timely supply of water for irrigation

You will learn about these practices in some detail in the following pages.

The climate in our country is variable throughout the length and breadth of the country. Taking advantage of the climatic variations, a large number of crops are cultivated in our country.

CROP PLANTS

Crop plants can be classified in several ways. One of these would be by taking into consideration the products obtained from them as shown below:

Cereal or grain crops. Rice (Fig 23.1), Wheat, Barley, Oats and Maize.

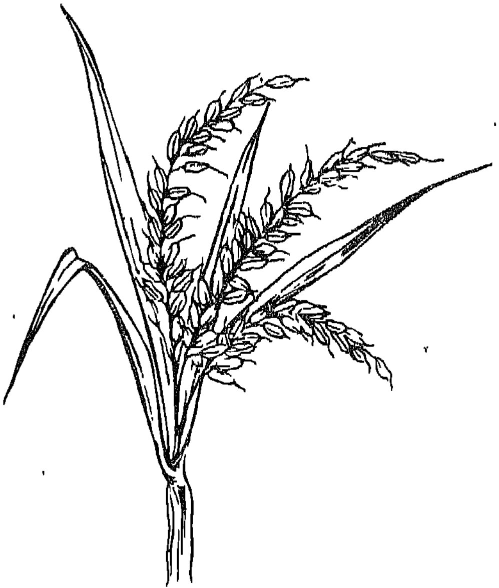

Fig 23.1. Grain crop : Rice.

Millets: *Sorghum* (Jowar or great millet), *Ragi* (finger millet) and *Bajra* (pearl millet).

Fiber crops· Cotton and jute.

Pulses (Legumes): Red gram (pigeon pea, *Arhar*, *Tur*), Black gram (*Urad*), Green gram (*Moong*) and Bengal gram (*Chana*).

Beans: Peas, Soyabean, Cowpea, Lentil grain and Groundnut.

Oilseeds: Linseed, Mustard, Groundnut, Soyabean, Sunflower, Safflower, Castor and Cotton seed.

Root Crops: Carrot, Turnip and Sweet Potato.

Tuber Crops: Potato, Tapioca, Ginger and Turmeric.

Sugar crops: Sugarcane and Beet root

Plantation crops: Coffee, Tea, Rubber and Coconut.

You may collect some of the different plants growing in your neighbourhood. Examine their external characters and differences.

HORTICULTURAL CROPS

You know what horticulture means. Horticulture deals with the growing and production of vegetables and fruits and the management of orchards and parks. The cereal content of the Indian diet is unusually large. The increasing population requires increase in the production of cereals. This has its own limitations. It is very essential to take to supplementary and substitute forms of nutrition such as vegetables, fruits, milk, milk-products, egg, poultry, animal fats and proteins in human diet.

At present the diet of an average Indian contains 30 gm and 80 gm of vegetables and fruits respectively. His counterpart in the advanced countries consume 316 gm and 362 gm of vegetables and fruits respectively. Thus, there is a greater need for increasing the production of horticultural crops Moreover, vegetables provide proteins, carbohydrates, mineral salts and vitamins

The following are some examples of the vegetables and fruits of our country:

Vegetables. Potato, Tomato, Brinjal, Cabbage, Onion. Lady's finger, Garden pea, Radish, Beet root, Turnip, Carrot, Beans and Leafy vegetables.

Fruits Apple, Plantain, Orange, Guava, Grape, Mango, Papaya and Pineapple.

TEST ITEMS

1 What is agriculture ?
2. What is horticulture ?
3. What is the position of agriculture in our country ?
4. What are the four important factors which influence crop production ?
5. What are the main constituents of soil ?
6. Describe the roles of water and sunlight in the production of crops.
7. What are the inputs necessary for increasing agricultural production ?
8. Name some agricultural and horticultural crops of your locality.

CHAPTER 24

Various Agricultural Practices

1. Man has improved his agricultural practices. The improvement is continuing. New methods have always ensured better crop production.
2. The lost fertility of the field may be restored by cultivating a pulse crop between two cereal crops.
3. Through experimental breeding of plants it is possible to improve the quality of the plants.
4. Many plant diseases are carried by the seeds.
5. Weeds in a cultivated field compete with the crop plants for water, nutrients and sunlight.
6. It is possible to raise two to four crops in a year in the same field.

THE yield of a crop can be increased by following a number of improved practices from sowing to harvesting. Proper attention has to be paid to all the practices. Neglect of one or more of these practices leads to reduction in the yield. Implements required for use at the various stages of crop production should be good and effective. The use of tractors and allied machinery, which has been contributing significantly to the improved agricultural practices is broadly the same in different parts of the country but varies in detail from crop to crop. Various practices for increasing crop yields are continually being improved by agricultural scientists throughout the world. You will learn about the various agricultural practices one by one in the following pages.

ROTATION OF CROPS

If only one type of crop is grown in succession on the same field, the yield may decline and the crop may be more prone to diseases and pests. In order to avoid this, different types of crops are grown in succession in a field. A pulse crop is generally grown between two cereal crops to restore the fertility of the field.

VARIETAL IMPROVEMENT

The improvement of crop varieties is an ever continuing process in modern agriculture. Do you know that a number of wheat and sugarcane varieties of earlier years have gone out of cultivation and are replaced by better types? The varietal improvement is the work of the plant breeders. The following are some improved high-yielding varieties of certain crops

Rice	IR-8, Jaya, Padma, Bala, Jagannath, IET-1039, T-141 and Cauvery.
Wheat	Sarbati Sonora, Sonalika, Kalyansona, Hira Moti, RR-21 and UP-301 (Fig. 24 1)
Maize	Ganga-101, Ranjit and Deccan Hybrid.
Lady's Finger	Pusa Savani.
Brinjal	Pusa Purple, Long, Pusa Kranti and Muktakeshi.

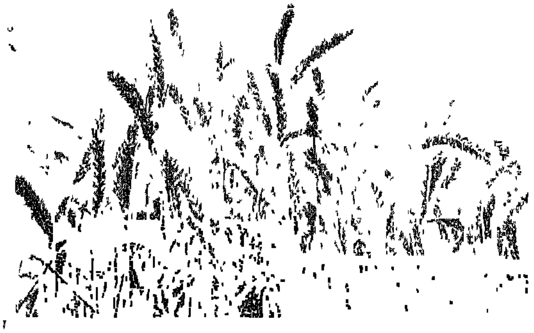

Fig. 24 1 An improved variety of wheat. (*Courtesy* . Directorate of Extension, Deptt of Agriculture, Govt. of India)

SEED TREATMENT

Treatment of seeds with fungicides is essential to check the spread of seed-borne diseases. The seeds are treated with chemicals like Agrosan or Ceresan. This treatment also protects the seedlings from the attack of many diseases.

SEED BED PREPARATION AND CARE OF SEEDLINGS

In the case of paddy and many vegetables, the seeds are first sown in a nursery bed and only after they attain certain age they are transplanted to the main field. The seed bed is properly ploughed and prepared so that it should be soft and loose enough to permit the growth of the tender roots. The level of the seed bed is kept uniform in order to ensure uniform distribution of irrigation water. Frequent and adequate irrigation in nursery is very essential as the plants at this stage are more likely to dry up than the adult plants. It is necessary to remove the weeds as they compete with the crop plants for water, nutrients and sunlight. Seedlings must also be protected from the attack of diseases and pests by spraying chemicals like Parathion, Sevin, Dimecron and Rogor.

TRANSPLANTING

The practice of planting the seedlings from the nursery to the main field is known as transplanting. Transplanting allows for selection of seedlings, better penetration of roots in the soil and better shoot development. Transplanting is a common practice in the cultivation of rice and many vegetables. This is practiced sometimes in wheat cultivation also. The main field is appropriately ploughed and manured When the seedlings are 4 or 5 leaved, transplanting is done During transplanting, proper distance is kept between plants and rows to enable the plants to receive sufficient sunlight and water, and for easy interculture.

FERTILISER APPLICATION

To obtain better yields it is necessary to apply fertilisers Fertilisers are applied keeping in mind the natural soil fertility and crop requirements The total amount in case of nitrogenous fertilisers is applied in split doses, two or three times, while others are added basally at the time of transplanting You will learn more about the fertilisers in the following lesson

IRRIGATION

For the survival and proper development of plants, irrigation is necessary Roots fail to develop and elongate in a dry soil. The number of tillers (aerial branches in cereals) also get reduced in a dry soil The crop is irrigated according to its water requirement and soil characteristics. Irrigation practices, in cereals thus vary for different types of crops and soils. Irrigation is essential during the seeding, tillering, flowering and grain filling stages of the crop. There should be provision for draining the excess water. The rice plant tolerates standing water (water logging) in the field, while in the case of other crops like maize and vegetables the excess water must be drained out. Heavy rains during the harvest season of cereals cause crop losses.

WEED CONTROL

Weeds are undesirable plants in crop fields The weeds are classified as graminaceous (*Monocotyledonous*) and non-graminaceous (*Dicotyledonous*) weeds. *Hariali* or Doob grass (*Cynodon dactylon*) is a graminaceous weed. *Choulai* (*Amaranthus* sp), growing in a field of tomatoes, is a dictoyledonous weed. Weeds compete with the crop plants for water, nutrients and sunlight and thus grow at the expense of crop plants The weeds are first removed before sowing or transplanting by hand-weeding or using a plough or a harrow Weeds reappear during crop growth and are removed either by hand-weeding or by spraying weedicides (weed killing chemicals) like 2, 4-D (2, 4 Dichlorophenoxy acetic acid), MCPA (4-chloro-2-Methyl 1-phenoxy acetic acid) and Simazine Several spraying appliances are in use today to apply these chemicals.

CONTROL OF PLANT DISEASES AND PESTS

Crop plants are attacked by a number of diseases, which lead to considearble crop losses. These diseases are caused by fungi, bacteria and viruses Some diseases are transmitted through the seed and are called the seed-borne diseases Others are soil-borne or air-borne. Various fungicides are available to control the diseases Some of the high yielding varieties of crop plants are susceptible to several pests which are generally of the insect group. By spraying pesticides (Fig. 24.2) or following other control measures, the pests can be controlled. You will study in detail about the control of plant disease and pests in a later lesson.

Fig. 24 2. Spraying of pesticides on wheat plants. This prevents several diseases of the crop.

(*Courtesy* Directorate of Extension, Deptt. of Agriculture, Govt of India)

USE OF PLANT GROWTH REGULATORS

The researches in plant physiology have resulted in the development of a number of chemical substances which influence the growth and development of plants. There are many types of these chemicals which have specific action on plants ; they are auxins, gibberellins cytokinins, abscisin and growth inhibitors These growth regulators have found a place in modern farming techniques, particularly in the case of horticultural crops for growing better quality produce.

MULTIPLE CROPPING

One of the contributing factors to the increase in food production in India is the multiple cropping. This involves raising two to four crops in succession in a year from the same field. This becomes possible by proper management and by the use of short duration varieties of crops. Proper irrigation facilities are essential for multiple cropping Through this technique we can now harvest upto four crops whereas it was not possible to harvest more than one or two in the past Multiple cropping has not been adopted in all regions of our country. Its extension holds the key to the food problem of India.

In order to learn the different agricultural practices, you must visit the nearby agricultural farms or vegetable gardens You should try to grow a kitchen garden either in your home, or in school, or in both the places By this experience you will learn much. Moreover, whatever little you will produce, will increase our country's food production.

TEST ITEMS

1. Name the various agricultural practices
2. Why is it advisable to grow a pulse crop between two cereal crops ?
3. Name the different varieties of rice and wheat commonly cultivated in your locality
4. Why do the seeds need chemical treatment before sowing? How can a seed bed be properly prepared ?
5. Why is transplantation required in certain plants? What are the steps to be taken for proper irrigation ?
6. What are the common weeds found in an agricultural field ? How can they be controlled ?
7 Name a few chemicals which act as plant growth regulators
8. What do you understand by multiple cropping ?

CHAPTER **25**

Manures and Fertilisers

1. Plants require many mineral nutrients
2. Manures and fertilisers must be applied to crops for obtaining good yields.
3. Manures and fertilisers are organic substances and chemical compounds.
4. There are various types of manures and fertilisers in use

You know that green plants have the unique capacity for synthesising complex organic substances utilising simple inorganic substances from the soil and atmosphere In the event of absence or deficiency of these nutrients, the plant will not be able to carry out photosynthesis and other synthetic activities. Plants depend entirely on the soil for all their nutrient supplies Continuous farming on the same land depletes the mineral nutrients of the soil. It is essential to enrich the soil with manures and fertilisers every time a crop is grown for a rich harvest.

Various crops have different nutritional requirements. Table 25.1 indicates the quantities of nutrient elements removed from a hectare of land by paddy and wheat crops

TABLE 25.1

Crop	*Nitrogen* N (Kg.)	*Phosphate* P_2O_5 (Kg.)	*Potash* K_2O (Kg.)
Paddy	69	24	93
Wheat	85	34	73

Fertiliser application in India is very low compared to that in highly productive countries. Table 25.2 indicates the fertiliser application in India (average) and other countries and the yield per hectare of land.

TABLE 25.2

Country	*Kg. of fertiliser used per hectare*	*Yield per hectare*	
		Paddy (Kg.)	*Wheat* (Kg.)
India	20	1150	1158
West Germany	155	—	2869
Japan	234	4659	2148

Increased application of fertiliser offers wide scope for the improvement of crop yields. This is one of the important agricultural practices adopted by the progressive farmers in India and which has caused higher yields.

PLANT NUTRIENTS

Green plants require the following essential elements to complete their life cycles carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, manganese, copper, iron, zinc, boron, molybdenum and chlorine

You know that except carbon, hydrogen and oxygen which are obtained from air and water, all the other elements are obtained from the soil.

NEED FOR THE APPLICATION OF MANURES AND FERTILISERS

The deficiency of any one or more of these elements retards the growth and development of the plant. Ultimately the yield of the crop plant is affected The plant develops characteristic symptoms due to the deficiency of each of these elements. These are called deficiency symptoms or 'Hunger Signs' of the crops. Amongst the essential elements, nitrogen (N), phosphorus (P), and potassium (K) are required in much larger amounts by the plant Referred to as NPK, these are also called the primary elements.

You have learnt that crop plants impoverish the soil and there is need to replenish the exhausted soil nutrients by the application of manures and fertilisers Leaching by rain water and soil erosion also remove the nutrients from the soil. A heavy rain after the application of fertilisers causes serious loss of the nutrients.

Growing a leguminous crop is one of the common practices to enrich the soil with nitrogen-containing compounds Their root nodules contain bacteria which are able to utilise the atmospheric nitrogen. These bacteria convert the nitrogen from the air into nitrogen compounds. So, growing a leguminous crop in crop rotation enriches the soil

TYPES OF MANURES AND FERTILISERS

Manures · Manures are organic materials which supply all the elements a plant needs, but only in small amounts. Besides serving as sources of nutrients, the organic manures improve the physical condition of the soil

The various types of manures are. Farm yard manure (FYM), green manure and composts.

Farm Yard Manure : It is the most valuable organic matter commonly applied to the soil. This is readily available even to a small farmer having a few cattle This usually consists of dung, remnants of straw and other materials like cattle urine. In our villages a good amount of cow dung, which is a rich manure, is burnt as fuel due to the non-availability of any cheap fuel. To convert into manure the cow dung is to be properly stored in a pit. It is necessary to dig the pit under shade and keep the dung moist. The manure becomes ready after four to five months.

Green Manures: A quick maturing crop is raised and ploughed back into the field. This benefits the succeeding crop. The leguminous crops like *Dhaincha*, Cluster beans, Sunn hemp, Cowpea, Horsegram and others are grown as green manure crops.

Composts: This consists of all the cattle-shed wastes and all the available refuse from the house These include straw, farm weeds, vegetable refuse, groundnut husks and other substances. All these are properly mixed together and used as manure after rotting. This is known as the rural compost In recent years, the municipalities are also composting the waste materials from the cities.

Fertilisers: Fertilisers are generally grouped as follows: Nitrogenous fertilisers, phosphate fertilisers and potassium fertilisers.

Fertilisers quickly furnish the available nutrients to the plants. In recent years, attention is being paid to the application of other essential nutrients besides NPK. The following are some of the usually available fertiliser compounds.

Nitrogenous fertilisers . Ammonium sulphate, ammonium nitrate and urea
Phosphate fertilisers · Superphosphate, bone meal and rock phosphate
Potassium fertilisers Muriate of potash (KCl) and sulphate of potash (K_2SO_4)

The NPK fertilisers are also available as mixed fertilisers These are now manufactured by different companies in India. Specially mixed fertilisers are available for different crops. Special care should be taken while applying the fertilisers to the nursery to avoid injury to the seedlings. Adequate moisture in the soil must be provided following application of fertilisers. Application of fertilisers is profitable when irrigation facilities are available or in regions with assured rainfall.

TEST ITEMS

1. Why is it necessary to apply fertilisers and manures to the soil ?
2. Name five essential nutrients of the green plant.
3. How does a green plant obtain nitrogen ?
4. What do you know about different kinds of manures ?
5. What are the different groups of fertilisers ? Name the fertiliser compounds of each group

CHAPTER 26

Crop Diseases, Pests and their Control

1. Crop diseases exhibit characteristic symptoms
2. These diseases can be controlled by spraying fungicides or by other control methods.
3. The crop pests are mainly insects.
4. The crop pests can be controlled by various control methods

PLANT diseases and pests cause serious losses in food production You have seen that crops are raised with great care and expenditure but a sudden outbreak of a disease can bring about severe losses in crop yields Crop diseases and pests not only contribute to serious losses in crop yields but also act as human health hazards. You know about the nature of pathogens and pests. Prevention of their occurrence is as important as their control after the outbreak. The use of disease and pest resistant varieties of crops is the ideal solution. Attempts are in progress to develop such improved varieties of different crop plants

DISEASES OF CROP PLANTS

Crop plants suffer from a number of diseases (Fig. 26.1). These are caused by microorganisms like fungi, bacteria, mycoplasma and virus The microorganisms obtain their nutrients from the plants. They either infect a part of the plant or the entire plant The infected part becomes damaged or killed. Various diseases and pests can damage the crop to an extent of 10-30 per cent losses in the yield. The great Irish femine in 1845-46 was due to a devastation of the potato crop caused by a fungus, *Phytopthora infestans*. The Bengal famine in the year 1942-43 was caused partially by the serious devastation of the rice crop by a fungus *Helminthosporium oryzeae*

COMMON DISEASES OF PLANTS

Some of the common diseases of crop plants with their characteristic symptoms are given below. The plant diseases are commonly known

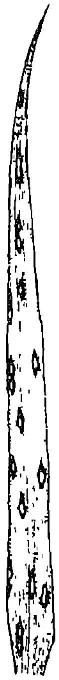

Fig. 26.1. Paddy-blast on the leaf of a paddy-plant.

as blights, leaf spots, mildews, wilts, cankers, rusts and smuts.

BLIGHTS	Some varieties of rice are susceptible to bacterial disease called leaf blight. (A fungal disease in potato known as potato blight).
LEAF SPOT	Plants having fungal disease called leaf-spot develop characteristic spots on the leaf, e.g. potato, groundnut (Fig 26.2), cotton.
POWDERY MILDEW	This is a fungal disease. The affected part of the plant develops light grey cottony patches on the leaf, e g. potato, lady's finger, apple and grapes.
WILTS	The cotton plant is subjected to a wilt disease caused by a a fungus. Leaves turn yellow and droop.
CANKERS	This is a very common bacterial disease affecting the lime plants. The leaves and fruits show brown raised out-growths.
RUSTS	Brown rust of wheat (Fig. 26.3) and sorghum is a common fungal disease. Orange coloured round or oblong ruptured areas appear on the leaves
SMUTS	This is a common disease of rice, sugarcane, wheat, maize and sorghum. The ears and grains are transformed into greenish black

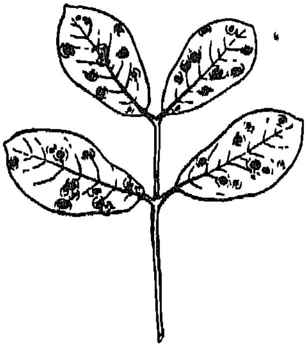

Fig. 26.2. Leaf-spot due to tikka disease of groundnut.

mass. (Figs. 26.4 and 26.5).

VIRAL DISEASES

Viruses cause a number of plant diseases like mosaics. The disease is carried by aphids, leaf-hoppers and other insects.

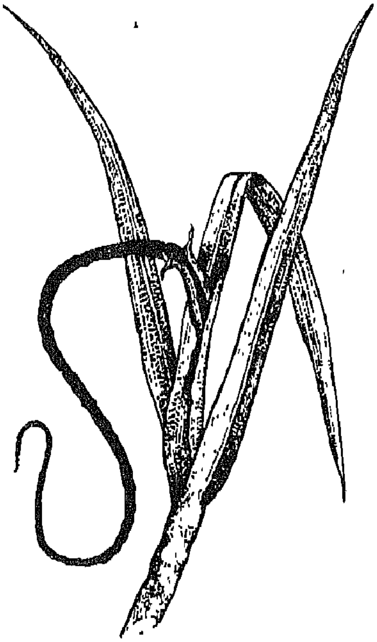

Fig. 26.4. Sugarcane Smut.

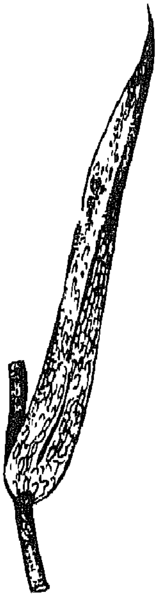

Fig. 26.3. Brown-rust of wheat.

MYCOPLASMA DISEASES

Mycoplasma resembles bacteria (bacteria without cell wall) A number of diseases like general yellowing, smallness of leaves. transformation of floral parts into leaf-like structures are caused by mycoplasma, e g brinjal little leaf, rice yellow dwarf and sandal spike

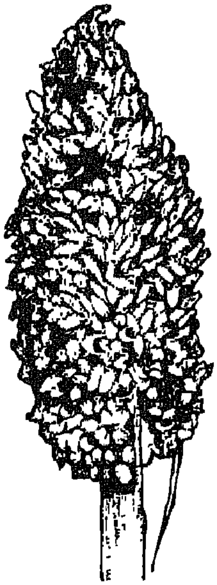

Fig 26.5. Grain-smut of jowar

These are also transmitted by insects like thrips and leaf-hoppers.

CONTROL MEASURES

Crop rotation: This is one of the common practices for controlling crop diseases Absence of a particular host leads to the disappearance of the pathogen or the causal organism. You may recall that the parasites are very specific in the choice of their hosts.

Seed treatment: A treatment of seeds before sowing eradicates the diseases transmitted through seeds The fungicides like Agrosan GN and Cerasan are used in controlling the seed-borne diseases. Viral diseases normally cannot be prevented or cured except through the destruction of the carrier organism. Some of the seed-borne diseases are controlled by hot-water or hot-air treatment. The use of disease-free seed or the removal of the propagating material is the best control method.

Plant Quarantine Measures: The imported seeds and plants should be free from diseases. Enforcement of quarantine regulations is essential for the prevention of the entry of new diseases into the country through imported plant material. For this they are pre-screened and sterilised.

Breeding: Controlled breeding of crop plants which are resistant to the diseases is one of .the best methods of disease control Sonora-64 variety wheat and I.R. 8 variety rice are resistant to some diseases.

Control of Diseases by Fungicides and Antibiotics: Control of diseases by chemical treatment is called plant chemotherapy. The commonly used fungicides are compounds of copper or sulphur. They are known as copper fungicides and sulphur fungicides respectively, other fungicides include organo-sulphur and organo-mercurial compounds. The fungicides are applied in appropriate concentrations and amounts, either in a'powder form or as liquid sprays. Different manufacturing companies have different trade names for the fungicides manufactured by them. Some of the commonly used fungicides and antibiotics are given below:

1. Copper fungicides: Bordeaux mixture, Blitox and Fungimar.
2. Sulphur fungicides. Sulphur powder and wettable sulphur
3. Carbamate fungicides: Thiram and Nabam
4. Organo-mercury fungicides: Agrosan GN and Phenyl Mercuric Acetate (PMA).
5. Other organic fungicides. Captan, Disulfoton and Karthane.
6. Antibiotics: Aureofungin, Agrimycin-100, Streptomycin and Cyclohexamide.

ANIMAL PESTS OF CROP PLANTS

Various animals cause considerable damage to the crops and cause severe crop losses. Most animals feed on crop plants and also the produce during storage. The insects feed on the plants in the field as well as on grains in the storage, often resulting in severe losses. These losses can be minimised by improved grain-storage practices. Many of the plant diseases are transmitted by insects. The intensity of pest attack varies and may lead to either partial or complete crop failure. The following are some of the insects which affect plants.

CHEWING INSECTS

Larvae and adults of grasshoppers and beetles usually attack the crop They feed on the foliage and tender grains They either bite or chew the plant parts.

SUCKING INSECTS

Plant-bugs, aphids, leaf-hoppers are some of the examples of sucking insects. Swarms of these insects usually attack the plants They suck the cell sap by piercing through the epidermis of the vegetative parts and developing grains These are also particularly responsible for transmitting mycoplasma and viral disease

STEM BORERS

The larvae of the insects after hatching from eggs bore into the stem and feed on the inner tissues This leads to the withering of the main shoot Some examples of such insects are rice stem-borer and sugarcane stem-borer

TERMITES AND WHITE ANTS

The attack by these begins at the roots and spreads to the aerial parts This results in the withering of the plant.

STORAGE PESTS

Weevil is an example of the notorious pest of paddy and wheat during storage. They feed on the grain, and lay eggs inside the grains. After hatching, the larva eats the grain There is colossal loss of food grains due to weevil during storage The loss is not merely in terms of quantity but also in the quality of food grains

LOCUSTS

Locusts closely resemble grasshoppers They are migratory and fly very long distances during migration. The desert locust is global in its distribution, extending from India to Africa The locusts destroy crops and wipe out vegetation

In addition to insects several other animals also destroy the crops. Various birds like sparrows, parrots and pigeons consume a considerable part of the grains. The worst animal pest is rat. The rats destroy plants in the fields and grains in godowns and houses

CONTROL OF ANIMAL PESTS

It is always necessary to keep the fields and gardens free of weeds Weeds not only compete with the crop plants for water, nutrients and light but they shelter insects and diseases. Weeding is an important practice of pest control Uproot diseased plants and burn or bury them

Plant Quarantine: As in the case of plant diseases, quarantine measures are very essential in the case of imported varieties Steps must be taken to see that the insects are not imported into the country at various ports of entry

Chemical Control: It may be noted that plant breeders are constantly striving to evolve varieties and hybrids resistant to pests and diseases. In the technology of crop protection chemical control is the best available method. There are several types of insecticides available.

1. **Systemic insecticides**· These get absorbed by the plant tissue and continue insecticidal function for extended periods
2. **Contact insecticides:** These are toxic to insects upon contact.
3. **Fumigants:** These produce vapours or fumes which are toxic.
4. **Poison baits and traps:** The insects or other animal pests feed on them and die.

Spraying or Dusting The pesticides can be applied either as dusts or liquid sprays. A variety of spraying and dusting equipment are available Pesticides are equally toxic to men and animals Many of these pesticides are highly poisonous and must be used with sufficient care. They should be kept away from the reach of children It is advisable to take best control measures immediately after the first signs of disease or attack appears. Preventive control measures can be taken when a pest attack can be anticipated. In certain cases, some State Governments are undertaking large scale control measures by aerial spraying. It is a good practice to pick up the ready-to-harvest vegetables before pesticides are applied. It is also equally essential to harvest the vegetables a few days after the application of pesticides.

Biological Control In view of the problems associated with the use of pesticides, the use of biological control methods for pests and insects is more safe The large scale release of the natural enemies of crop pests which feed on the pests is becoming increasingly popular This is by far the safest method of pest control. The natural enemies of pests are multiplied in large numbers and released in large numbers in the field One of the best examples of biological control of crop pest is the use of *Trichogramma* wasp. These wasps feed on the eggs of sugarcane boring insects and thus destroy the sugarcane pest In the control of sugarcane scale insect also biological control measures are being employed by releasing predator insects in large numbers

TEST ITEMS

1. What are the different kinds of diseases of crop plants ?
2. Name the common diseases of rice, wheat and cotton plants
3. What are the different control measures suggested for combating plant diseases ?
4. What are the common insect pests that affect the crop ?
5. Besides insects, what other animals destroy plants ?
6. How would you control the different animal pests ?
7. Name the functions of different insecticides. Give examples.

CHAPTER 27

Improvement of Crops

1. It is possible to improve the quality of crops through selective hybridization and mutation.
2. For plant breeding, the important steps are selection of the right variety of plants, artificial crossing and repeated cultivation of new seeds in the proper regions
3. It is possible to induce artificial mutation through a number of physical and chemical agencies
4. The success of a new variety depends greatly upon its introduction and acclimatisation.

SINCE the beginning of this century, with the emergence of genetics, the crop improvement programme has been brought to scientific level Crop improvement through breeding now forms the backbone of modern agriculture

The improvement in crop plants is necessary for increasing the yield and improving the quality of crop. Such improvement is achieved not through breeding alone. For a long time, man has been using various methods for improving the crops These methods are ploughing the land, irrigation and protecting the crop from diseases With the development of scientific knowledge and the demand for more food, various new methods for crop improvement are continuously adopted. These practices as you have already learnt are in the form of providing better manures and fertilisers, protecting crops from various diseases and giving proper irrigation facilities. Breeding for better seeds, introducing and selecting plants from different localities and acclimatising them and inducing mutations are some of the permanent measures for crop improvement. In this chapter you will study various topics in relation to these aspects.

BREEDING

The main aim of plant breeding is to produce new crops superior to their existing counterparts By plant breeding method, new varieties resistant to pests and diseases for higher yield and short duration are being evolved The plant breeder achieves this by artificial crossing or hybridization Hybridization increases genetic variability. Desirable characters from two or more varieties of plants can be combined by hybridization Hybridization may be effected between different varieties of the same or different species

A systematic process is followed to get a better quality of breed First of all the parents with the desired characters are selected. In the nearly mature bisexual flowers, the anthers are removed with the help of fine forceps. It is done to avoid the chances of self-pollination. Then the emasculated flower is covered with a paper bag, and tagged properly. The tag contains the name of the parent plant, time and date of emasculation and other details After some hours or days, depending upon the crop, the viable pollen grains from the other selected variety are applied on the mature receptive stigma of the emasculated flower.

The fertilisation takes place and all the seeds are collected upon maturity They are sown and only the plants with desired characters are selected. The seeds of these plants are resown .The cycle of crop raising and selection continues for several generations. Thus, plants with constant characters are finally obtained, which are released to the farmers in different parts of the country.

The NP-52 variety of wheat is a result of a cross between the NP-6 and Pb-9 varieties. It is a high yielding variety with good quality of grain.

The Sone 227, Kalyan 227, Kalyan 567, Pb-18, Sonalika 308, Sarbati Sonora, S-331, UP 301, RR-21 are some of the varieties of wheat developed in India. The IR-8, R-20, Padma, Jaya, Sabarmati and Cauvery are some of the improved varieties of paddy. Besides, there are various improved varieties of bajra, jowar, pulses, maize, sugarcane, jute, tobacco and vegetables which are cultivated throughout the country.

MUTATION

From your earlier study you can understand the role of mutation in the organic evolution De Vries defined mutation as the process of sudden, discrete and discontinuous changes found at chromosomal level It is a sudden heritable change in an organism. The mutations can be induced artificially by atomic radiation and different chemical substances

Mutations help in raising a new variety of crop plant much faster than any other method. However, the use of mutation in crop plants is limited and needs more exploration. A variety of wheat, resistant to black and brown rust disease, was developed by mutation The rice with fine grain and tomatoes with more redness were developed with the help of mutation. In India various improved varieties of wheat were produced with the help of mutation. An example is NP 30 with more tillering capacity, dwarf size, and better grain quality.

INTRODUCTION AND ACCLIMATISATION

It is one of the easiest and most rapid methods of crop improvement. The process of introducing new plants from their old locality to a new locality with different environment is called introduction. And their adjustment under this changed environment of the new locality is called acclimatisation.

The introduction of plant may be from one continent to another, as the 'Ridley' variety of wheat introduced in India from Australia. The litchi and loquat were introduced into India from China. There are also inter-state introduction of plants. The NP wheat varieties were introduced to other states from Delhi.

For thousands of years travellers, pilgrims, invaders, explorers or naturalists have been responsible for the introduction of plants from one area to another. In India, the invaders brought cherries and grapes from Afghanistan and Iraq by A.D. 1300. In 1510, people from Portugal introduced maize, groundnut, chilli, potato, papaya and tobacco into India. The East India Company introduced tea, litchi and loquat from China and cabbage and cauliflower from the mediterranean region. The botanical gardens also helped in introducing new plants in different regions. For example, the quinine and rubber plants were introduced in India from the New World by the Kew Botanical Gardens, London.

PROCEDURE OF INTRODUCTION

In the past, the process of introduction was very simple and required only a transporting agency. But due to the development of scientific knowledge, the various steps of the process are analysed scientifically and systematic attempts at introduction were made. The process includes the study of the utility of a plant, its type, place of growing and place of introduction, checking, packing and transport of the material.

SELECTION

Selection is one of the oldest procedures of crop improvements. The selection of better quality of crops for further cultivation is also utilised for improving the crop production. In nature, the best adaptive variety of a crop survives while the rest are wiped out in course of time. This is the phenomenon of natural selection and forms a link in organic evolution.

The selection of better varieties of crop can be made artificially from a mixed population. Sometimes the progeny of a single plant with better yield are selected for further cultivation In case of vegetatively propagated crops such as sugarcane, banana, potato, onion, citrus etc., a crop is obtained from the single better yielding plant.

In other cases, the bud is selected for further cultivation. Kalyan Sona 227 variety of wheat, resistant to brown rust disease, is selected from the population of the S-227 variety. Ganga and Vijaya, two important selections of wheat, are resistant to black rust disease.

TEST ITEMS

1. What are the different measures for improving the crops ?
2. What conditions are necessary for proper plant breeding ?
3. Describe artificial pollination.
4. How are the mutations caused ? Is it possible to produce artificial mutation ?
5. Name a few plants which were introduced into our country from outside.

CHAPTER **28**

Hybrid Vigour

1. A hybrid usually shows more vigour than its parents.
2. The vigour of a hybrid may be expressed either in the entire plant or only in a part of it.
3. The introduction of new and desired hybrids has increased our food production.
4. The success of a hybrid depends upon several conditions which are to be fulfilled in agricultural practices.
5. The hybrid may lose its vigour in successive generations.

You have studied some of the improved varieties of crops in the previous lesson. The improved varieties give higher yield and show increased resistance to diseases. The increase in the yield of crops is brought about by the increase in the size of fruits or seeds. Plant breeding techniques offer wide scope for crop improvement. Hybridization is an important breeding technique for combining the desirable characters from two or more varieties. Hybridization may be effected between varieties, species or even genera. Hybrid corn produced by controlled pollination showed more vigour than open pollinated varieties.

Cultivation of hybrid corn in the U S.A. resulted in tremendous increase in production. As a result of constant efforts high yielding varieties of maize, sorghum and pearl millet are developed mostly following hybridization technique. A real breakthrough in productivity has been achieved following heterosis breeding in these crops.

The hybrid vigour is defined as the increase in size or vigour of a hybrid over its parents. Another term *heterosis* (Gr. *Heteros*=different, *osis*=condition) was also proposed to denote increase in size and vigour after crossing. Both terms are used synonymously.

Effect of Hybrid Vigour : Heterosis does not affect an individual as a whole but only a specific part of it. For example, the root is affected in carrot, the stem in potato, the leaf in cabbage, the fruit in pea. The effect of vigorousness in crops may be expressed in three ways.

These are quantitative effects like an increase in size, number of fruits and seeds. The biological effects exhibited are increase in biological efficiency of an organism, like the capacity of reproduction and ability for survival. Thirdly, the physiological effects exhibited are resistance to various diseases and early maturation of the plant. The extent of effect depends upon the origin and relationship of inbreds. The increase in yield may be 30 to 60 per cent in radish and other plants. In some cases, a negative effect of heterosis is also noticed.

PRACTICAL APPLICATION OF HYBRID VIGOUR

The effects of hybrid vigour are manifested in many ways in the plants. Increase in the vigour, size, height of the plant, number of roots are often used as indications In self-pollinated crops, hand pollination is generally necessary to produce hybrid seeds In cross-pollinated crops, male sterile parents are utilised.

Table 28.1 indicates the mode of pollination in some crop plants in which hybrid vigour has been utilised.

TABLE 28.1

Mode of pollination	*Examples of crop plants*
Cross pollination	Maize, sugar beet, radish, and cabbage.
Self pollination	Rice, sorghum, cotton, tobacco, tomato, brinjal, lady's finger.

Table 28.2 indicates some of the examples of hybrids of crop plants.

In tomato a three-fold increase in yield has been obtained in the hybrids. It is due to the increase in the size of fruit, number of fruits, number of branches and height of the plant. In brinjal, the yield increase is more due to the increase in the number of fruits than in size. In hybrid cotton (e g. Hybrid-4, Varalaxmi) the size of the boll increases and upto 160 per cent higher yields have been obtained with better fiber quality. In paddy hybrids, the size of the grain, the number of tillers, the length of panicle and the height of the plant increase and the crop matures earlier. In sorghum and lady's finger higher yields upto 60 per cent were obtained.

TABLE 28 2

Name of the crop	*Hybrid*
Maize	Deccan, Ranjit, Hi-starch, Ganga, Deccan-101
Sorghum	CSH-1, CSH-5
Pearl millet	HB-1, HB-3
Cotton	Varalaxmi, CBS-156

In maize, the hybrid varieties gave maximum yield which is brought about by an increase in the size of cob, size of grain, height of the plant and the number of cobs. Hybrid maize varieties even produced better quality fodder. In sugarbeet and radish, the size of root increased resulting in an increase of 60 per cent yield. In cabbage, the size of leaf and its weight increased, while in sunflower the increase is in the oil contents of the seeds was noticed

UTILISATION AND LIMITATIONS OF HYBRIDS

Hybrid vigour has been of immense practical utility in the improvement of crops, but there are still certain limitations In the case of self-pollinated crops, the process of hand-pollination is a tedious and expensive operation So it is difficult to fulfil the farmers' demand for hybrid seeds In cross-pollinated crops, the vigour decreases rapidly in succeeding generations and it becomes difficult to maintain the level of vigour of the plant In the case of vegetatively propagated crops, the desired hybrid vigour can be easily maintained and multiplied by vegetative propagation without any difficulty In recent years efforts are being made by plant breeders to develop composite varieties known as composites The composites are equally high yielding as the hybrids. Composites have the added advantage over the hybrids in that the farmers can preserve and sow their own seeds.

TEST ITEMS

1. What do you mean by hybrid vigour ?
2. How is the vigour of a hybrid expressed ?
3. Give some examples of plants showing hybrid vigour.
4 What are the limitations of using a hybrid ?

CHAPTER 29

Elements of Animal Husbandry

1. Man has been domesticating animals since prehistoric times.
2. Animals which we need are of three categories . milk giving animals, meat and egg giving animals and draught or working animals.
3. Our demand for food can only be met partly by improving the livestock.
4. Proper care and management are required for improving the livestock.
5. Domesticated animals are also victims of various diseases

SINCE the dawn of history, man has been domesticating animals in order to use them for work and for food. In the process of domestication, he developed methods for their care, for their feeding and for getting better breeds of animal. For a long time man has been raising the kinds of animals he wanted. For example, dog has been a companion of man for a long time. The animals he raised were livestock like cattle, sheep, pigs and poultry. This knowledge, in course of time, has developed into the science of animal husbandry.

IMPORTANCE OF DOMESTICATED ANIMALS

India is a predominantly agricultural country Livestock, such as cattle, sheep, goat, camel, horse, mule, yak, pig and fowl play an important role in the rural economy of India. On the basis of utility the livestock can be categorised into three main heads.

MILK GIVING ANIMALS

Cows, buffaloes and goats provide us with milk. Milk is a perfect natural diet. Milk and its products like curd, cheese, ghee are nutritious food.

MEAT AND EGG GIVING ANIMALS

Ducks, fowls, pigs, sheep and goat are the main sources of meat. The poultry also provides us with eggs

DRAUGHT OR WORKING ANIMALS

Bullocks, buffaloes, camels and horses are used for doing work in the fields They are also used in transporting essential commodities. Mules are very useful in military operations in mountainous terrain

Besides the above functions, the livestock provide us with horns, feather, skin and leather. Their droppings and urine are used as manure to enrich the soil fertility.

NEED OF ANIMAL HUSBANDRY

According to the 1961 census, India has a large livestock population of 336.4 million. Inspite of having a large number of milch animals, milk production in India is meagre. The average annual yield of milk per cow is very low and there is wide scope for augmenting the yield.

Table 29 1 indicates the average per capita milk consumption per day in India and some other countries.

TABLE 29 1

India	130 gm
U S. A.	623 gm
New Zealand	637 gm
Switzerland	741 gm

We have in our country 80 4 million working cattle This works out to a pair of working cattle for every 3.8 hectares of cropped area. The cow dung and urine are the common natural manures In India about half of the total cow dung is utilised as fuel. Urine also is usually wasted. Cow dung is being increasingly utilised recently as a fuel in gobar gas plants. It can be used this way both for fuel and later as manure.

There is wide scope for increasing the production of meat and eggs in our country. To meet the needs of the population, the production of these is to be increased by about 20 times.

Table 29.2 indicates the annual per capita poultry meat consumption in India and other countries

TABLE 29.2

India	0.13 kg
U. S A.	13.18 kg
European countries	2.47-5 95 kg

MANAGEMENT OF LIVESTOCK

The main handicap in the promotion and growth of livestock industry in India are

1. Adverse climate and environmental factors.
2. Poor genetic potential of the majority of the livestock.
3 The shortage of feeds and fodders

The problem can be tackled to some extent by adopting improved methods of managements and breeding. You will learn about animal breeding in the next chapter.

MANAGEMENT

Here the word management is used in a very wide sense and includes feeding, mating, providing drinking water and treating the sick and diseased animals

FEEDING

Proper feeding is very important to make the inherited qualities of the livestock effective. The cattle feed must be rich in nutrients. It should comprise of carbohydrates, fats, proteins, minerals and vitamins. The cattle feed can be divided into (1) roughages and (2) concentrates.

Roughages They include the straws of cereals They are fibrous, coarse and of low nutrient content in general

Concentrates : They include cotton seed, oil-cakes, cereal grains, bran etc. They are rich in one or more of the nutrients.

An average cow needs a daily ration of 15 to 20 kg green fodder, 4 to 5 kg of dry grass, a good amount of grain mixture and 32 litres of water.

Feeds given to the poultry chiefly consist of cereals, or their by-products. The modern feed for the poultry is the all-mash diet It is a mixture feed.

Sheep thrive on natural grasses, herbs and farm wastes They are generally not given any grain except when they are to be fattened for meat. Pigs should be given feed of comparatively low fibre content such as cereal grains and their by-products

HOUSING

To get the maximum production from animals, it is necessary to provide them protection from excessive rain, heat and cold The cattle should be housed in comfort in houses with proper sanitation and ventilation. Drinking water should also be made available to them There should be a proper drainage system and arrangements for the waste removal

Sheep and goats do not require any special housing arrangements. They can be kept in an open yard, fenced with dried thorny hedges and partially covered with thatched roof Pigs should not be kept in overcrowded and damp houses. Poultry is housed in wire cages or in the poultry houses.

WATER AND WATER SUPPLY

Pure water in sufficient quantity is a necessity. The amount of water consumed by animals will depend to some extent on the nature of its food, its size and functional activity and the seasons. To ensure good health cattle should be regularly groomed They should be washed and bathed once or twice a week

Table 29.3 indicates the average daily requirement of water for different animals.

TABLE 29 3

Cows	27-36 litres
Pigs	5-23 litres
Poultry	240 ml
Elephant	90-113 litres
Camel	68-90 litres

SOME COMMON DISEASES OF ANIMALS

The diseases of animals can be grouped under several categories.

VIRAL DISEASES

1 Pox found in cows, buffaloes, sheep, goats and fowls
2 Dermatitis found in goats and sheep.

DISEASES CAUSED BY BACTERIA AND FUNGI

1. Tuberculosis in cattle and birds
2. Fowl cholera
3. Contagious bovine abortion
4 Calf diphtheria
5. Necrosis of feet and tail
6. Diarrhoea of chick
7. Foot-rot of sheep

In addition to these there are several other diseases found in animals Many of the diseases can be controlled by adopting proper sanitary measures, controlling diets and housing the animals in comfort Animals should be given vaccination at younger ages

Everyone benefits from animal husbandry The farmer benefits from an additional source of income The consuming public benefits from an increased supply of meat, milk and eggs The nation benefits because of the permanent improvement made in its agriculture and soil conservation made possible by livestock farming Successful animal husbandry is the basis for sound and continuous soil conservation

TEST ITEMS

1 Explain why some animals have been domesticated by man
2 Describe the uses of the following animals. (i) Cow, (ii) Dog, (iii) Camel, (iv) Duck, (v) Pig, (vi) Buffalo and (vii) Horse.
3. Inspite of the large population of cattle in our country, milk production is meagre—Why ? How do you improve the milk production ?
4 What steps are to be taken for proper management of livestock ?

CHAPTER 30

Animal Breeding

1. In order to improve the livestock, varieties with desired characters must be selected.
2. The use of good quality breeds gives good return in poultry and cattle management.
3. A number of breeds from other countries have been introduced in India to improve the quality of our livestock.
4. Artificial insemination is a scientific method to produce calves of better quality.
5. Fish serves as a very important source of food. We have abundant fish fauna.

You have studied that animals are kept in good health by proper feeding, housing and care. You have also studied that the parental characters are passed on to the offspring during the process of reproduction. So, in order to improve the stock, it is necessary to exercise a control of characters passing from parents to offspring. If the parents bear sound characters, it is likely that next generation will also be good.

In your previous lesson you have also studied that in spite of having a large number of livestock in India, we still do not get the maximum return from them in milk, meat and eggs The working capacity of the animals is also very low in general. The main handicap perhaps is the shortage of superior breeds. A breed is a group of animals of common origin within a species that has certain distinguishing characteristics not found in other members of the same species. As the number of superior breeds is less, artificial insemination programme is also introduced in the breeding of cattle in India. Breeding with a superior breed helps in improving the livestock.

IMPORTANT INDIAN BREEDS

There are about 26 breeds of cows and

6 breeds of buffaloes in India. Some of these produce more milk and others are more hard working. There are breeds having both the qualities. The females of the dual purpose breeds are fairly good milk-yielders and the bullocks are good for draught purpose.

Exotic Breeds used in India : As you know the milk yield per cow in India is low So, to improve the milk yield a number of exotic breeds of bulls are being used for cross-breeding with indigenous cows. Some of these are : Jersey, Holstein, Friesian, Ayreshire and Brown Swiss.

THE BREEDING PROCESS

The age of maturity in cattle depends upon various factors. These factors may be breed, feeding, environment and health. In India, the cattle generally mature at the age of three years. When a cow is in heat period it shows signs of restlessness and loss of appetite. At that time a bull should be selected carefully for breeding. The bull should belong to the high milk-yielding stock. A bull also matures at about the same age of three years. Generally, one bull is sufficient for 60 to 70 cows of breeding age. The number of females can be increased to 100 if the bull is fed properly.

The milch cow selected for breeding should be vigorous and healthy. It should have a good mammary system. The udder should be symmetrical and soft. The teats should be well shaped, uniform and of good size.

ARTIFICIAL INSEMINATION

A bull can be mated to as many as 50-60 cows normally. In artificial insemination a bull has been mated to as many as 10,000 cows situated at different places. Artificial insemination has ~~many advantages. It is more economi-~~ cal It makes possible a wider use of the superior bulls. The semen from bulls of distant places can be used. The spread of diseases can also be controlled. The general procedure of artificial insemination is collection of semen, its examination, injection of the semen into the female and a study of the results of insemination.

POULTRY FARMING AND BREEDING

The term poultry includes chickens and ducks Poultry keeping can be started with a limited amount of money. It requires only a small plot of land and a few birds Meat and eggs can be sold immediately to get the return. It is advantageous to use breeds of high egg laying qualities.

Poultry plays an important part in the production of egg and poultry meat. Thus it plays a dual role in increasing the production of human food and in raising the income of the farmer.

IMPORTANT BREED OF POULTRY

A name 'Desi' is given to the native fowls. Desi hens are small and slow growing. They are ideal mothers and good sitters They are hardy and possess natural immunity against common diseases. Aseel, Busra, Chittagong and Ghagus are some of the examples of the 'Desi' breeds. Exotic breeds of fowls used in our country are White Leghorn (Fig. 30.1), Rhode Island Red and Black Minorca. These breeds are being widely used in breeding programmes to upgrade the Desi fowl

SELECTION OF BREED

Poultry keeping is a business. It is, therefore, very important to select the right type of chickens for breeding If you intend to produce birds for poultry meat industry, the selection of chickens should be limited to the fast growing chickens. If you intend to have poultry for more eggs, then ckickens possessing high laying qualities should be selected. Hens possessing inherited characters for egg production will give better results. However, poorly developed birds should be killed immediately.

PIGGERY

Pigs are the most prolific breeders. They are most efficient converters of feed into meat. A unit of 10 sows and a boar will produce 160 piglets during the first year. In addition to lard (fat) the pig bristles are very useful. Pig rearing can give quick returns on a low investment.

The common village pig is a slow grower and the pork is of very low quality. To upgrade the Indian pigs the boars of some of the exotic breeds have been used. This has given good results with the minimum outlay. The important exotic breeds used are . Large White Yorkshire, Middle White Yorkshire and Berkshire.

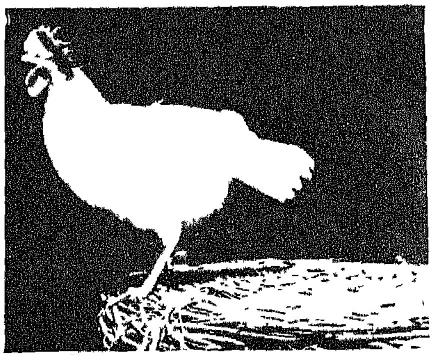

Fig. 30 1. A white leg-horn pullet
(*Courtesy* . Directorate of Extension. Deptt of Agriculture, Govt. of India)

PISCICULTURE

Fish play very important role in meeting the food requirements of the country, especially in providing the much needed protein. The economies of some countries are based largely on their fishing industries. Development of fisheries has been assigned high priority in view of its vast potential in our country. Also, fishing industry is a very good earner of much needed foreign exchange. Over a thousand species of fishes occur in India.

On the basis of distribution, the fish fauna of India may be broadly classified under two groups, namely fresh water fish and marine fish. Many marine and fresh water forms are edible. Potentially the vast and varied fishery resources of India are one of the richest in the world. In the smaller water bodies that can be manipulated by man fishes can be cultured; this process is known as pisciculture. In the larger bodies of water, such as, rivers, estuaries and large reservoirs fishes grow naturally. Man has only to reap without having to sow and this is known as capture fisheries.

Marine fishery deals with the fishery aspects of sea water or ocean. Until recently sea fishing operations in India were restricted to a narrow coastal belt. It should also be noted that science of fishery includes the study of certain other animals as well. These animals are being exported to various parts of the world and are good foreign exchange earners.

Some examples of fishes and allied animals are

Fresh water fishes	*Catla*, *Labeo*, *Cirrhinus*, *Cyprinus*, *Barbus*, *Mystus*, *Tinca*, *Heteropnuestes*, *Channa and Clarias*
Sea water fishes	Indian shad, *Hilsa ilisha* Mackerel, Cat fishes; Bombay duck, Gar fish, Half beaks, Red

	mullet, Ribbon fishes, Flying fishes, Oil sardines, Mugil, Silver bellies, Caranieids, Butter fish, Sardine and White bait.	Allied animals	Marine prawns (shrimps), Lobsters ,edible molluscs such as Mussels, Cephalopods and Clams; Edible oysters, Pearl oysters and Chanic fish

The seas around us represent one of our most valuable resources The sea offers possible solution to food problem the world is facing today

TEST ITEMS

1 Why is it necessary to use good breeds of livestock ?
2. What are the different exotic breeds used in India to improve the cattle ?
3 What is artificial insemination? What is its advantage ?
4. Name the different domestic and exotic breeds of fowl in India
5. Why is piggery more economic than poultry ?
6. What is pisciculture ? What are the principal varieties of fresh water fishes available in India ?

UNIT— 6

HUMAN BIOLOGY
HEALTH
AND
NUTRITION

CHAPTER 31

Functional Anatomy of Human Reproductive System

1. Male and female reproductive organs in human beings are complex systems which develop and function under the influence of hormones.
2. An adult female produces one ovum per month while an adult male produces millions of sperms.
3. The menstrual cycle in the females is associated with changes in the entire female reproductive system.

MALE REPRODUCTIVE SYSTEM

The main male reproductive organs are the testes The associated or accessory organs are the epididymis, the seminal vesicles, the prostate and the penis (Fig. 31.1).

TESTES

They are two in number. Each testis is oval in shape and lies within a thick fibrous covering which is enclosed in skin, the scrotum.

Each testis contains seminiferous tubules which join to form 15-20 larger tubes opening into the epididymis

The functions of the testes are to produce spermatozoa and male sex hormones. The process of production and maturation of sperms is called spermatogenesis.

Spermatogenesis: The seminiferous tubules are lined with the germinal epithelium on its inner side These cells divide a number of times to produce spermatozoa. During these divisions, meiosis occurs. Meiosis results in the reduction of number of chromosomes from 46 to 23 in each spermatozoon (sperm) In animals, spermatogenesis occurs only in breeding seasons. In man, after puberty, spermatogenesis takes place continuously until it stops in the old age. Spermatogenesis is dependent on the presence of male sex hormones – the androgens. These hormones are produced by the interstitial cells which lie in the interstitial space between the seminiferous tubules. After puberty the hormones are produced in larger quantity

The anterior pituitary, through the action of its gonadotrophic hormones, controls the functional activity of the testes

Since sperms are continuously produced they pass into the seminiferous tubules and the larger tubules and then into the epididymis

EPIDIDYMIS

This is a tube like structure which is firmly attached to the testis and is connected with the seminiferous tubules Epididymis is the main storehouse for sperms

A sperm consists of three parts The head contains nucleus The middle piece contains mitochondria and is responsible for energy release The tail is long and the sperm swims in the fluid by means of whiplike action of the tail

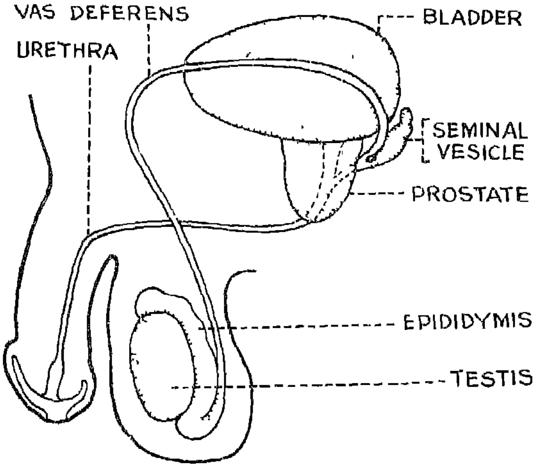

Fig. 31 1. Reproductive organs of human male

The sperms reaching the epididymis are immature, non-motile and have a very low fertility In the epididymis, they mature, become motile and develop their fertilising power

They then pass into the vas deferens The vas deferens is a tubular structure with a muscular wall with non-ciliated epithelium on the inner side The sperms partly swim and are mainly moved along by muscular action of the wall of the vas deferens. The vas deferens connects the epididymis to the seminal vesicle

SEMINAL VESICLES

These are a pair of thin walled muscular, elongated and lobulated sacs. They lie at the base of the urinary bladder above the prostate gland They both join to form the ejaculatory duct

They secrete a viscous fluid which forms much of the volume of the ejaculated seminal fluid.

PROSTATE

The prostate is closely applied to the urethra towards the urinary bladder It is of the size of a whole round arecanut and has about two dozen ducts which open into the urethra The prostate produces a fluid—the prostatic fluid —which gives the semen its characteristic odour

The fluid together with the secretion of the seminal vesicles are released into the lumen of the urethra

The prostate does not have any counterpart in the female

URETHRA

The urethra is a muscular tube beginning at the urinary bladder. It passes through the penis to the tip of the glans penis. The urethra is also the passage through which urine is voided Thus, the male urethra functions both for the reproductive system and for the urinary system.

FEMALE REPRODUCTIVE SYSTEM

The female reproductive system consists of the two ovaries, the fallopian tubes, the uterus and the vagina (Fig. 31.2).

OVARIES

There are two ovaries. Each is an oval body lying in the pelvic cavity. At birth each ovary contains about 250,000—500,000 ova but the majority degenerate during the lifetime. Only about 400 ova mature and are released in a normal human life span. In addition, the ovaries produce two hormones : the oestrogen and the progesterone. These hormones cause a number of changes of which the following are important :

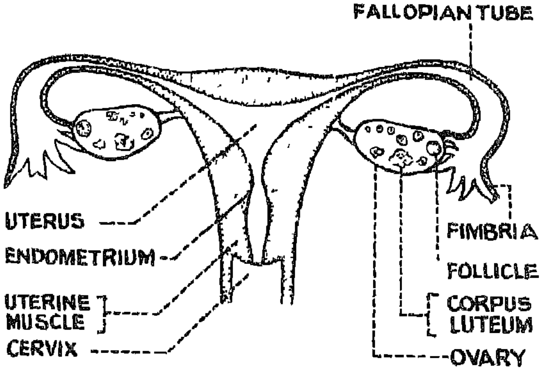

Fig. 31 2. Reproductive organs of human female.

1 Growth and development of the uterus, fallopian tubes and vagina at the puberty.
2. Regular monthly bleeding—the menstrual cycle.
3 Appearance of secondary female sex characters.
4. Changes and development of the mammary glands.
5. Changes that take place during pregnancy.

FALLOPIAN TUBES

The fallopian tubes are muscular tubes which are attached to the uterus at one end. The other end of the fallopian tube expands into finger like projections called fimbriae. This end lies close to the ovary When the ovary releases an ovum, the fimbriae pick it up and convey it through the fallopian tube to the uterus In the tube, it is moved along by the ciliary lining of the tube and also partly due to muscular contraction of the wall. If the ovum is fertilised, it develops into an embryo. If it is not fertilised, it is discharged through the cervix and vagina during the next menstrual flow.

UTERUS

The uterus is a hollow muscular organ within which the embryo develops It lies between the urinary bladder in front and the rectum behind. It is pear shaped and is 7.5 cm in length, 5 cm in breadth and 3.5 cm in thickness It has a large upper part—the body, and a lower narrow part known as the cervix. The cervix protrudes into the vagina. The fallopian tubes are attached to the upper part of the uterus as shown in Fig. 31.2. The wall of the uterus is thick and muscular and encloses a cavity. The cavity is lined by a layer of cells forming the endometrium The chief function of the uterus is to provide the place for the ovum, when fertilised, to grow into an embryo.

VAGINA

The vagina is a tube like structure which extends from the vulva to the level of the junction of the cervix with the body of the uterus. The vagina is normally in a collapsed state with the anterior and posterior walls in contact with each other Vagina acts as a receptacle for the spermatozoa necessary for fertilisation of the ovum.

TABLE 31.1

OVULATION AND THE MENSTRUAL CYCLE

Phases	*Time of cycle*	*Changes in ovary*	*Hormones*	*Changes in the uterus*	*Ovum*
Menstrual	1-4th day	Follicle formation	Oestrogen secretion begins	Shedding of the endometrium with bleeding	Discharged with menstrual flow
Post menstrual or proliferative	5-13th day	Follicle growth and maturation	Oestrogen	5-13th day formation and proliferation of new endometrium	Maturation in the follicle
Ovulation	14th day	Rupture of follicle to release the ovum	-do-	Proliferation of endometrium and increase in the blood supply	Ovum released, picked up by the fimbriae of fallopian tube
Premenstrual or progestational	15-19th day	Transformation of follicle to corpus luteum and its maturation	Oestrogen and Progesterone	-do-	Transport to the uterus. Fertilisation may occur
	19-25th day	-do-	-do-	-do-	Implantation of the ovum if fertilisation occurs. If not fertilised, it is expelled
	26-28th day	Degeneration of corpus luteum	Rapid fall in the level of both the hormones	Degenerative changes of endometrium begin	
Menstrual	1st day of next cycle				

OVULATION

The ovum with its surrounding layer of cells is called a follicle. Towards the middle of a menstrual cycle one follicle develops rapidly (Table 31.1). The cells multiply and the centre of the follicle degenerates and becomes fluid As more fluid collects. around the 14th day before the next cycle, the follicle ruptures. The ovum loosens and discharged from the ovary This process is known as ovulation

The ovum is picked up by the fimbriae of fallopian tube and passes through the fallopian tube on its way to the uterine cavity Before ovulation occurs. only oestrogen circulates in the blood stream. From the second day after ovulation, till another 10-12 days both oestrogen and progesterone are present in the blood stream

When the ovum has been released, the ruptured follicle heals. The healed follicle without the ovum is called the *corpus luteum* which matures and persists over the next 12-14 days. If the ovum is not fertilised, it degenerates towards the end of the menstrual cycle. If fertilisation occurs, the corpus luteum continues to grow and produces hormones, mainly progesterone, for several months. It starts to degenerate at about the sixth month of pregnancy

These hormones i e oestrogen and progesterone. are essential for the proper growth of the endometrium The level of hormones falls rapidly during the last three days of the cycle if fertilisation does not occur Then on the first day of the next cycle bleeding starts with the passage of the endometrial tissue and the unfertilised ovum. The endometrium is completely sloughed off in an average of four days time The slaughed off endometrium and the blood constitutes menstrual flow

It is important to note that ovulation occurs 14 days before the next menstrual cycle Thus, ovulation occurs on the 14th day of a 28-day cycle or on the 16th day of a 30-day cycle The anterior pituitary influences the ovulation through at least three hormones Hypothalamus of the brain controls the secretion of these gonadotrophic hormones by the anterior pituitary

TEST ITEMS

1. List the main parts of the male reproductive system
2. Enumerate the main parts of the female reproductive system.
3. Describe the different stages of the female menstrual cycle
4. Describe the formation of functional sperms

CHAPTER 32

Pregnancy and Child Birth

1. There is only a limited time span during the menstrual cycle when a female can become pregnant.
2. The foetus derives all its nutrition from the nutrients in its mother's circulation
3. The foetus faces many dangers and hazards during development.
4. Several changes occur in the new born immediately after birth

FERTILISATION

It is estimated that the ovum is not capable of being fertilised 48 hours after ovulation Spermatozoa also live for approximately 48 hours after discharge. If sperms are introduced into the vagina within 48 hours of ovulation, fertilisation may take place The sperms swim from the vagina through the cervix and uterus to reach the ovum while it is still in the fallopian tube. About 200 million sperms are discharged in each ejaculation by the male Many sperms die even before reaching the uterine cavity, but many viable sperms reach the ovum. However, only one sperm fuses with the ovum. Thus fusion of one ovum and one sperm results in the formation of a zygote The fertilised ovum reaches the uterine cavity and gets embedded in the endometrium The corpus luteum of the ovary does not degenerate but proliferates and secretes hormones, mainly progesterone. The endometrium does not undergo degeneration and the menstrual flow does not occur. The female complains of having missed a monthly period and becomes pregnant

PREGNANCY

The duration of pregnancy is, on an average, 280 days or 40 weeks from the last menstrual cycle. During pregnancy certain changes take place in the mother

The uterus shows the most marked changes It enlarges in size and reaches the level of the margin of the mother's ribs by the 36th week. The weight of the uterus increases steadily until the delivery of the baby. The blood supply to the uterus increases The foetus and placenta within the uterus grow in size. Later the foetus can be felt through the abdominal wall The amniotic fluid, in which the foetus floats, increases in quantity The abdomen of the expectant mother is distended due to the enlargement of the uterus and its contents. Dark lines appear on the abdomen They form white marks after delivery The breasts enlarge in size The nipple and the area around it become darker. They produce a secretion in the late months of pregnancy After the birth of the baby, milk is secreted for the new born. The expectant mother gains in weight during pregnancy

Pregnancy puts new demands on the mother since she has to take enough nourishment for herself and for the growing foetus. The extra weight has to be carried by her. There are changes in the composition of her body fluids and circulating hormones. There are some mental and emotional stresses on the mother.

DEVELOPMENT OF THE FOETUS

When a sperm fertilises the ovum, the product is called a zygote. The zygote undergoes repeated cell division and gets implanted in the endometrium by the 24th day of the menstrual cycle. Cell division, which starts even before implantation, continues. By the 4th week a hollow mass of cells is formed

By the 5th week the mass of cells differentiates into three germinal layers Each layer later forms different functional organs and systems. This period constitutes the germinal period or germinal stage of the foetus.

The embryonic stage begins with the 6th week when small buds appear for the organs like brain, heart, lung liver, etc Buds for the limbs are also formed By the end of the 6th week a primitive circulatory system is established.

During the next three weeks the hands and feet can be recognised The organs and systems, *viz.*, digestive, respiratory, nervous systems and external sex genitalia, develop during this period.

By the 10th week the embryonic stage is over and the foetal stage begins By the 12th week all essential features, recognisable in later life, are present, though not fully developed. Between 18-20 weeks, the foetal heart beats can be heard through the mother's abdominal wall

During the next eight weeks of pregnancy the foetus continues to grow and the organs mature further. At the end of this period the length of the foetus is about 35 cm and its weight is about 1 3 kg.

From 28-36 weeks there is deposition of fat which gives the foetus a plump appearance. The length of the foetus at this time is about 45 cm and it weighs 2 to 2 5 kg During the last four weeks, the foetus is fully mature and is delivered around the end of the 10th lunar month or 40 weeks

NUTRITION OF THE FOETUS

The foetus derives its nutrition from the mother. All nutrients including oxygen are obtained from the mother's blood stream. The placenta is the organ which develops during pregnancy and is attached to the inner surface of the uterine wall. The umbilical cord attaches the foetus to the placenta The full-term placenta is 500 to 1000 gm in weight or about 1/7th weight of the foetus. The umbilical cord has two arteries and a vein. These arteries branch and ramify and form a spongy mass which is attached to the uterus The fine capillaries of the placenta are always bathed in small pools of maternal blood. The maternal and foetal circulations remain distinct, but are separated only by the wall of the capillary through which foetus is able to receive all its nutrients and also transfer nitrogenous waste and carbon dioxide into the maternal blood.

HAZARDS TO THE PREGNANT WOMAN AND THE FOETUS

Foetus becomes viable at about 28 weeks when it weighs about 1 kg. Abortion is the termination of pregnancy before the foetus becomes viable, i.e. before it can live outside the uterine cavity. Abortion can be caused by defects in the foetus, decreased nutrition, maternal illnesses, trauma or a fall in the level of maternal hormones.

Physical hazards include damage to the foetus by X-rays in early months of pregnancy. Jumping or falling during pregnancy can cause abortion or the death of the foetus

Many drugs have harmful effects on the pregnant mother and the foetus. They may cause deformities of the foetus or retard its growth and development.

Certain diseases are much more severe in pregnant than in non-pregnant women. For example, influenza and measles (viral diseases) give rise to severe infections in the mother. Rubella virus infection of the mother during pregnancy is known to cause deformities or death of the foetus, or abortion of the foetus. Diseases of the liver (hepatitis) may be mild in the non-pregnant but may be fatal in pregnant women, especially in later months of pregnancy.

BIRTH OF THE FOETUS

At or about the 40th week of pregnancy labour sets in. Labour is the process by which the product of conception, when it has reached full term or is nearing it, is separated from the uterus and expelled through the the genital passage.

When labour begins, the uterine muscle contracts at intervals to push the foetus down genital passage.

The cervix becomes soft and it dilates. After some hours the vulva also dilates with the descent of the foetus. The frequency of the uterine contraction as well as the strength of contractions increase. The foetus is eventually expelled. Generally, the head is delivered first followed by the shoulders, then the body and finally the legs. At this stage the umbilical cord is tied and cut.

Labour continues until the placenta gets detached from the uterine wall and is also expelled. With the expulsion of the placenta, labour is complete.

In modern times surgery has helped to save many lives. The surgeon may assist the delivery if there are complications in order to save the mother or the foetus or to prevent any ill effects on either.

NEW BORN BABY

The new born has a sudden change of environment and must be protected. After birth a healthy new born infant is pink in colour, cries immediately and shows brisk movements of hands and feet.

The new born is very susceptible to changes in temperature and infections tend to be more severe.

The most dramatic change in the new born is that of respiration. The infant cries and the lungs expand; respiration starts. The new born now derives oxygen from the air and not from the maternal circulation as in intra-uterine life

Umbilical cord shrinks and shrivels and falls off later. Nutrition is now supplied orally. The best form of nutrition for the new born infant is the mother's breast milk.

TEST ITEMS

1. What changes occur in the mother's reproductive system soon after fertilisation ?
2. What are the main changes that occur in the mother's body during pregnancy ?
3. What are the main hazards to the foetus ?
4. Enumerate the different stages of development of the human foetus.

CHAPTER 33

Infancy, Childhood and Adolescence

1. The new-born infant requires a lot of care to face the environmental hazards.
2. Diseases or injuries which are trivial in adults may be fatal to infants.
3. A child of two years should have a diet similar to that of an adult.
4. Females complete puberty and adolescence on an average two years before males.

INFANCY AND CHILDHOOD

Infancy is that period of childhood which extends from birth to the age of one year. In this period, the child depends on someone for all its needs.

During the first three months of its life, the infant sleeps almost throughout the time, gets startled by noise or sudden movements and cries when hungry or disturbed.

During the next three months, the infant learns to recognise the mother and makes cooing and babbling sounds, takes notice of people around and occasionally smiles. Lying on the stomach, it can raise its head. When supported, it can hold its head erect and steady. The first teeth erupt.

By nine months of age, the infant crawls on four limbs and can sit erect. It can transfer objects from one hand to the other. It responds to its own name. Generally eight teeth have erupted by this time.

At one year of age the infant can stand and walk on its own, can speak simple words, play simple games and shows preference for some food and resents others.

By about one and a half years of age the child begins to understand words and simple sentences, enjoys playing alone and walking Indulging in a variety of activites it can run for short distances and attempts climbing.

At two years of age the child may express urge to go to the toilet, attempts to put on his clothes and can now run and climb. He plays more complicated games. His vocabulary is sufficient to make demands, to express joy and anger. He understands the relationship of his parents, brothers and sisters.

At birth the infant is completely dependent on someone for all its needs—nutrition, bath, changing clothes, protection from injury, etc.

At first only breast milk is given to the infant By three months some artificial foods, e g milk and cereals, are given.

By six months there is a changeover to other sources of food such as cereals and fruits. Milk and fruit juices form the bulk of the diet. Soft adult diet is introduced at this stage.

By one year the infant should be having almost all food items used at home, e.g., chapati, rice, dal, etc By this time milk is only of secondary importance in the infant diet However, the quantity is less and the intervals between meals are short.

HAZARDS OF INFANCY AND EARLY CHILDHOOD

Infants and children up to the age of five years face many hazards.

Malnutrition slows down the mental and physical growth of the infant and children. Malnutrition is a major problem in developing countries

Infections are more frequent and often more severe in infants than in adults Diphtheria, whooping cough and poliomyelitis affect infants and children more frequently but are preventable by vaccination Measles, chickenpox, diarrhoea and upper respiratory tract infections are also responsible for illnesses in children.

Infants tolerate extremes of temperature very badly, especially cold. Injuries due to fall are also more common among infants and children.

As the child grows he learns to avoid dangers. His vocabulary increases rapidly as he enters school. His ability to do some things for himself and his power of understanding increase. During the period from three to nine years, growth in height is slow but the child gains weight in a regular manner Sex consciousness is not very pronounced.

PUBERTY

Puberty is that phase of life when maturation of the reproductive organs takes place along with the appearance of secondary sex characteristics Puberty occurs around the age of 10-14 years It ends with the first menstrual cycle in females In males, it ends with spermatogenesis but the demarcation is not clear. Adolescence begins at the end of puberty.

There are some changes during puberty which are common to both males and females There is sudden spurt in physical growth The pubic and axillary hair begin to grow Psychological and emotional changes take place. There is a feeling of clumsiness. Both boys and girls become more conscious of the opposite sex and can now be embarrassed by them.

In females, the female sex hormones, oestrogen and progesterone, begin to be produced. Deposition of fat begins which gives the rounded curves to the body The uterus and ovaries enlarge. There is growth of the breast around the nipple. The first menstrual cycle occurs between the age of 13-15 years.

In males, the male hormones, androgens, are produced. Shoulders become broader than the hips The testes and associated male reproductive organs enlarge in size. Spermatogenesis begins. Occasional erections of penis and emission of seminal fluid occur. The voice becomes thick and coarse and acquires the male character.

ADOLESCENCE

Adolescence is the period from puberty to maturity. During adolescence the changes which started in puberty are completed.

At first, the menstrual cycle may not be accompanied by ovulation and may not be regular. During adolescence ovulation sets in with regular menstrual cycles. Further growth of the breast occurs.

The males also undergo changes in adolescence. Growth continues and muscle bulk increases. The hair growth on the face increases. Hair growth takes place on the chest.

Both sexes are very inquisitive during puberty and adolescence because at first they are not very sure of what changes are taking place in their bodies. The psychological and emotional conflicts of puberty are now slowly resolved. Adolescence ends at about 18 years, when the individual is considered mature and is now an adult.

TEST ITEMS

1. Enumerate the different stages of anatomical and functional development of an infant.
2. At what stage does the infant :
   (i) turn while lying ?
   (ii) sit erect ?
   (iii) stand on its own ?
   (iv) erupt the first pair of teeth ?
   (v) speak simple words ?
3. Mention the types of food given to infants at different ages up to two years.
4. What changes occur during adolescence in male and in female ?

CHAPTER 34

Maturity and Ageing

1. The reproductive period for the human female is limited to about 30 years.
2. Given adequate environmental conditions, no major changes occur in the human anatomy or functions up to the age of 35 years or so.
3. Ageing process starts right from the development of the foetus up to the old age.

THE ADULT

FROM the period of adolescence, the individual passes on to adulthood. This is the period when one assumes greatest responsibilities in his life such as having a family to continue the human species.

The reproductive age of a woman is from 15-45 years while that of a man begins at 15 years and extends beyond 50 years. From the adolescence onwards, the individual ceases to grow in height. However, in well-fed individuals there is growth in the girth of shoulders, chest waist, hips and also the arms, hands, legs and some addition to the muscle bulk.

In females, there is deposition of fat on the hips in the twenties. In the thirties fat is deposited on other parts of the body as well. The breasts become bigger and need support. This is because of the effects of pregnancy and suckling by the infant and deposition of fat.

As the age advances the physical activities of the individual decrease. The individual becomes less capable of strenuous physical activities.

At about 40 years, the hairs of the head begins to turn grey. At first there are just a few scattered grey hairs. Then a patch appears usually at the temples. Within next 10-15 years there are more grey hairs than black. In males the greying of hair also occurs on the face, but starts after grey hairs appear on the head.

In females, the reproductive period comes to an end around the age of 45 years. This phase is called menopause. At this age, the menstrual flow starts to diminish in quantity and flows for a shorter time. The time interval between each cycle increases. The cycles are not regular. The menstrual cycle eventually ceases.

The ovaries cease to function over the next three years after menopause and undergo atrophy The levels of oestrogen and progesterone fall. During this period of life, females undergo many psychological and emotional changes Later the uterus, fallopian tubes and vagina also begin to atrophy. The breasts also become atrophied.

AGEING PROCESS

The scientific study of the ageing process is called gerontology Ageing in fact starts from the development of foetus right through birth, infancy, maturity and old age.

The physiological functions gradually tend to reduce after the age of 35-40 years. But there are wide individual variations The ageing process reduces the capacity of the individual to stress and increases the period of the recovery after any injury Certain diseases are common during this period, viz , high blood pressure, arthritis and cancer The diseases of heart and cancer are two main causes of death during old age

Older persons usually show atrophy of certain tissues, specially of sex organs, skin, bones and connective tissues There is a decrease in the size of organs, the noncellular element increases.

Physiological and chemical properties of body colloidal systems undergo changes in the ageing process There is a decrease in functional activity of many normal cells and changes occur in the secretory activity of the digestive system, pancreas, liver, etc.

Blood vessels show fat deposits and reduced elasticity Changes occur in hormonal systems and nervous systems, many tissues and body cells get adversely affected. Atrophy of the nervous system may be due to gradual reduction of blood supply. Other cellular tissues of the body, such as blood forming centres and connective tissues and also the joints show fewer living cells

TEST ITEMS

1. List the main changess in tissues during the old age
2. Which diseases are more commonly seen during old age ?
3. List the changes which occur in middle age and menopause.

CHAPTER 35

Trends in World Population

1. Since the appearance of man one million years ago, this planet was sparsely populated and human population on this planet has grown very slowly until very recently
2. Migrations of populations and forcible occupation of territories of countries and continents have played an important part in the structure and growth of world population.
3. Nearly 70 per cent of the world population lives in less developed and developing countries.

A MERE collection of large number of people is not a population. Population always consists of a single species having a definite period of existence and well defined rates of birth, death, sexes and age structure. Demography is defined as the statistical study of population. Demographers study birth rate, mortality, migrations, ethnic groups, marriage problems, survival time, family size, etc

The problem of increasing human population is a recent one. Man appeared on the scene on this planet about one million years ago from hominoid apes who had evolved in Asia and Africa The population of man continued to remain small, sparsely spread over large areas of the planet Then it posed no problem as man multiplied at a rate which was less than 1 per thousand per year. Despite increase in populations in different continents and rise and fall of civilizations, the population continued its slow growth rate because of tribal wars, famines and epidemic diseases until about ten thousand years ago when it started rising rapidly.

The population of the world was estimated to be 300 million about A D. 1 From A D. 1 to 1750, the population increased by 500 millions representing an annual growth rate of 0 56 per thousand During the next 50 years, from 1750 to 1800, it rose to 4 4 per thousand By 1850, the world population shot up to about 1.3 billion and in 1900, the figure rose to 1.7 billion giving growth rates of 5.2 per thousand and 5.4 per thousand in the respective fifty year intervals. In 1950, the population was 2.5 billion, indicating an annual growth rate of 7.9 per thousand in the first half of the 20th century. During the last 25 years, the growth rate rose to 17.1 per thousand, raising the world population to 3.9 billion in 1974. At a growth rate of 19 per thousand the population will be 6.4 billion by the year 2000 (Fig. 35.1).

This sudden explosion of human population has created numerous problems which have compelled all nations and their planners to direct their efforts so that the population is maintained within reasonable limits according to the availability of resources for comfortable living of human beings.

WORLD POPULATION TREND

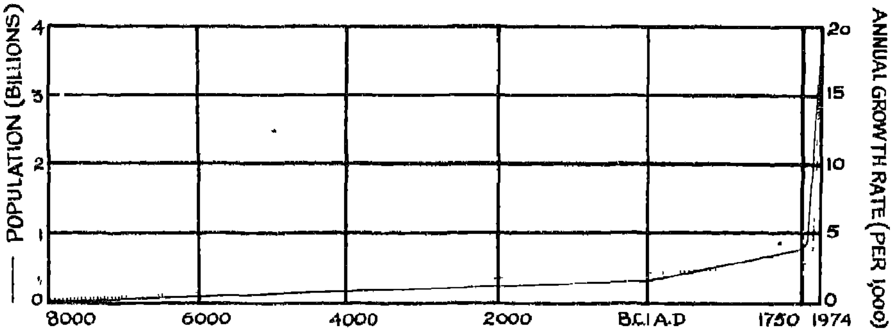

Fig. 35.1 Trend of rise in the world population.

In biological terms, if man devoted all his attention to the welfare of human species what is the population that this planet could sustain?

Several limiting factors like food, fresh water, minerals, oxygen, living space, energy requirements and environmental pollution have been mentioned. There is however, scope for overcoming some of these limiting factors if science and technology are used in the most rational manner. Man has so far drawn mineral and food resources mostly from the top few metres of the earth and there is a great deal to explore. Man has also used the resources of plants and animals from the sea to an extremely limited extent. However, the vast majority of the present world population cannot meet their basic needs, while a minority of 'developed' countries have so much food that they sometimes destroy crops to maintain prices. There are also eating habits which cannot be easily changed. Under such conditions the growth of population has to be kept down so that the limited materials produced can equal the demand; even families can balance their budgets and feed and clothe children if they remain small families.

The important factor in determining unequal distribution of human population on this planet has been the formation and appearance of nation states. Colonization, destruction of the original populations, slave trade from Africa and contract labour of South East Asian countries have played an important role in deciding the pattern of distribution and density of human individuals in different parts of the world during the last 400 years.

There are now countries in the world with high standard of living which are considered advanced and industrialised and countries with low standard of life, less industrialised, which are considered underdeveloped countries The population of the former is only about one billion. The remaining, more than 2½ billion as estimated in 1970, live in less developed countries of the world. Nearly 70 per cent of the world population lives in less developed countries and of this nearly 75 per cent lives in Asia.

Our past experience has been that the countries having relatively higher population density had progressed industrially only when they had exploited other people through imperialism, colonialism and expansionism. The population growth rate has steadily declined as the countries become industrialised, advanced and wealthy. The rate of growth of population in poor or less developed countries, on the other hand, continues to be high between 25 to 35 per thousand as against 10 to 15 per thousand in developed countries.

POVERTY AND POPULATION

The relationship between poverty and population in any country is very complex. It involves various socio-economic factors, in addition to the birth rates and death rates in a population These rates, in turn, are influenced by education, public health, hygiene, diseases and famine In the pre-independent India, industry, agriculture and social development suffered severe set-back Child death rate was extremely high, famines frequent and the average life span of the people low Because of these reasons, the actual rate of increase of population in India, under the British rule was markedly less than that of almost any European country and was almost at the bottom of the scale of population increase in the world. Population of the Indian sub-continent in the 16th century was estimated to be 100 million. In the 1941 census, it was found to be 361 million. The population of England and Wales in 1700 was only 5.1 million. It rose to over 40 millions in a little over two centuries which' is nearly double than that of Indian sub-continent rate.

Only after 1921, the population growth rate in the Indian sub-continent started increasing slowly, and more rapidly after independence. But the problems of poverty in India do not date either from 1921 or from 1951. In fact, Indian people were much poorer under the British rule and have made considerable economic advance since independence.

TEST ITEMS

1. What are the parameters of the science of demography?
2. List the possible limiting factors to human population on this planet.
3. What is the relationship between poverty and population?

CHAPTER 36

Population Problem in India

1. The population of India was only about 100 million in the 16th century.
2. The population of India has grown at a lesser rate in the 19th century and the early part of this century than those of many countries of Europe.
3. The infant death rate in India remains high and yet the population has risen at a rate of over 20 per thousand in very recent years.

ACCORDING to the census of 1971, India's population was 548 million which was double the number recorded in 1921 (Fig. 36.1).

TABLE 36.1

POPULATION IN INDIA IN DIFFERENT YEARS

Year	Total population (in million)
1901	238.3
1911	252.0
1921	251.2
1931	278.9
1941	318.5
1951	361.0
1961	439.1
1971	547.9

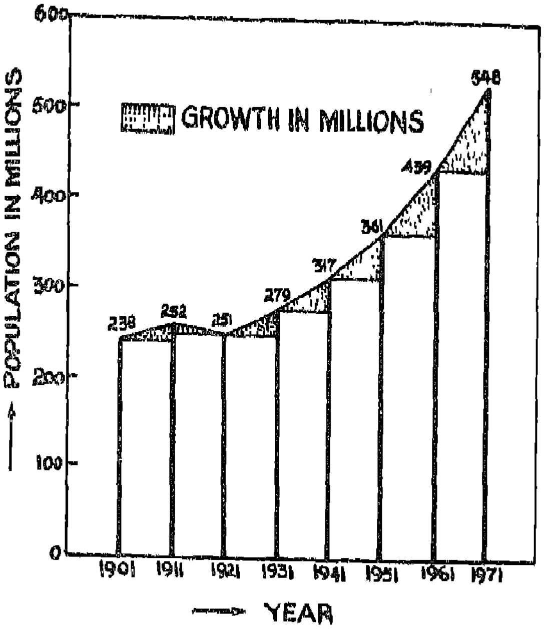

Fig. 36.1. Increase of population in India in this century.

India's population in 1901 was estimated to be 238.3 million. Up to 1921 the population had increased only to 251 2 million. The death rate was over 40 per 1,000 till 1921 and has steadily declined and is now about 16 per 1,000 for the rural population and only 10 per 1,000 in the urban areas.

The increase of population in India between 1951 and 1971 was largely due to the decline in death rate and not due to sudden increase in birth rate. The major killers like malaria, smallpox, plague and cholera were largely controlled and eliminated and health services considerably improved during this period leading to a rise in expectation of life. During 1961-71, the population increased by about 25 per thousand per year. Fourteen States (Assam, Gujarat, Haryana, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orissa, Rajasthan, Tripura and West Bengal) and Union Territories recorded higher growth rate than the national average Seven States (Andhra Pradesh, Bihar, Himachal Pradesh, Karnataka Punjab, Tamil Nadu and Uttar Pradesh) had lower growth rate than the national average.

The sex ratio in 1971 was 930 females per 1,000 males The lowest was in Punjab with a figure of 865 females per 1,000 males. Of India's total population, 42 per cent was below 15 years of age and about 6 per cent above 60 years In 1971 about 30 per cent of India's population was literate. The percentage of literacy among males was 39 5 per cent while among females it was only 19 per cent. Kerala had the highest literacy of 60 per cent followed by Tamil Nadu and Maharashtra. The lowest literacy rate of about 19 per cent was found in Jammu and Kashmir.

The total number of illiterate among adults, in spite of the increase in literacy in younger age groups, has increased Literacy and education are important factors in family planning programmes for control of population.

The birth rate continues to be high and is around 40 per 1000 of the population. Kerala had the lowest figure in 1971—29.8 per 1,000 and Uttar Pradesh the highest figure – 46.3 per 1,000. Infant death rate continues to remain high. It was about 140 per 1,000 till a few years back. It is now showing a decline but the national average remains well over 100 per 1,000. The expectation of life has risen to over 50 years.

In 1971, India had 178 persons per square kilometre. West Bengal was the most densely populated State in India with a density of 504 persons per square kilometre. Nagaland had only 31 persons per square kilometre.

It has been estimated that if allowed to remain unchecked, India will add 1 2 million persons per month, an increase of about 14 million per year Predictions are difficult to make but unless controlled, India's population may cross the one billion mark by the turn of the century. India accounts for nearly 15 per cent of the world population though it occupies only 2 5 per cent of the land area.

INDIAN POPULATION POLICY

Vigorous efforts are now being made to educate the public and take measures so that the population growth rate is reduced. It is worth noting that when a country starts on the road to development and well being of its people, a fall in the infant death rate is an important factor which in most advanced countries is less than 20 per thousand live births as against over 100 in India. A reduction in infant death rate requires welfare of the mother and the child, adequate nutrition and health care, a rising standard of living and improvement of social life. The birth rate then starts declining on its own because of the prosperity and the consciousness on the part of the people Family planning as such looks after the health of the mother but by itself may not be adequate to control the population growth or to bring it down significantly unless vigorous disciplined efforts are made to increase industrial and agricultural production and for equitable distribution of the wealth created

While this is being done a variety of methods of family planning have been made available. The main objective of these methods is to prevent the fertilisation of the ovum by the male sperm The methods used are surgical, chemical, machanical and hormonal.

All these methods ,however, require a certain degree of health care because no methods of family planning is without risk to the health of the persons concerned

In the male, the main procedure used are to prevent the sperms from reaching the uterus. Research on how to alter the fertilising capacity of the male sprem, its transport from the testis to the seminal vesicles through the vas deferens and complete suppression of production of sperms is in progress Cutting the vas deferens does not allow the sperms to reach the seminal fluid

In the female, there are two avenues of approach Firstly, ovulation can be suppressed by hormones. Its transport through the fallopian tubes can also be affected. Endometrium of the uterus can be influenced by mechanical and hormonal procedures so that implantation of fertilised ovum does not occur. The other approach is to use various contraceptive procedures which prevent or destroy the sperms before they enter the cervical canal.

Drugs and surgical procedures are now-a-days available to abort the newly implanted fertilised ovum. Early pregnancy can be terminated by surgical means and also aborted at this stage.

TEST ITEMS

1 What are the reasons for increase in population growth in India after 1951?
2. Describe the measures by which birth rates can be lowered

CHAPTER 37

Communicable Diseases of Man

1. Diseases can be caused by pathogenic microorganisms present in the atmosphere, food, water, on the hands, on clothings, etc.
2. Vaccinations can prevent many diseases caused by bacteria and viruses
3. Proper hygienic methods can prevent almost all intestinal infections caused by bacteria, viruses, protozoa and helminths
4. The Government has instituted national programmes to control or eradicate many communicable diseases such as smallpox, malaria, tuberculosis, leprosy and cholera

HUMAN beings live in an environment which has many parasites and microorganisms These organisms, on entering the human body, may cause diseases Helminths, protozoa, fungi, bacteria and viruses are responsible for a large number of such diseases which are the prime cause of illness and death in this country

For infectious diseases there is always a source of infection, which may be a patient suffering from the diseases. One who harbours these organisms, but does not suffer from the disease is called a carrier The animal reservoirs such is in cattle and rodents, are sometimes the source for helminthic, parasitic and some viral infections.

The parasites and microorganisms must have a route of infection to reach the part of the body where they cause disease Direct contact with the patient is responsible for many skin, venereal and respiratory diseases. Indirectly, infectious agents may reach a healthy person through air, water, milk, food, fomites (inanimate articles including clothing) or through the bite of animals and insects.

On reaching the body of the healthy person, there is always an incubation period during which the parasites and the microorganisms mature before manifestations of the disease appear. Finally, for its own survival, the infectious agent should have a mechanism of getting out of the body of the patient in a living form to infect other hosts.

Human beings are generally protected from the attack of these parasites and microorganisms by the intact skin and by normal secretions like the acid of the gastric juice in the stomach or the capacity of the cilia in the bronchi to capture any particles inhaled. Once the organisms have gone in, many cells of the body are brought into action for cellular defence Simultaneously, a special class of proteins are produced in the blood which are called antibodies which specifically attack the parasites or counteract their harmful products. The host also reacts by various physiological mechanisms such as rise in temperature or diarrhoea to inactivate or eliminate the toxic products of microorganisms

In nearly all the infections of the human body, there is a rise in body temperature, an increased rate of heart beat, increased frequency of respiration, dry tongue, poor appetite, concentration of urine and changes in white blood cells circulating in the blood

Infections can be prevented by not allowing the parasites or microorganisms to reach the host or by increasing the resistance of the host by vaccination and immunization Treatment is possible with specific drugs, specially against bacteria and fungi and many parasites. Effective drugs for the treatment and cure of viral infections are yet to be developed.

In India the largest number of infections affect the gastro-intestinal tract

Among the bacterial infections, cholera, gastroenteritis, typhoid fever, dysentery and tuberculosis occur only too frequently Certain amoebae and flagellates also cause dysentery and diarrhoea Helminths like tapeworms, hookworms and roundworms can infest the human intestine. Among the viral infections, poliomyelitis and infectious jaundice most frequently infect man through this route of infection.

These infections occur because of ingestion of contaminated food, water or milk or contact through hands Prevention of these infections is possible by boiling the water or milk, eating freshly cooked food, preventing contamination of food and filtration and chlorination of drinking water Vaccines to protect against the typhoid, cholera and poliomyelitis are available.

Other infections which are caused by air-borne bacteria reach the human body through the respiratory tract Some of the diseases, such as sore throat, diphtheria, whooping cough and tuberculosis are caused by bacteria.

A large number of these diseases are caused by viral infections. This includes influenza, measles, chickenpox, smallpox, mumps, and meningitis Smallpox has been eradicated in this country but chickenpox and measles continue to occur, specially during childhood.

Control of these infections is rather difficult but prevention is possible by effective vaccination. Diphtheria and whooping cough are preventable by inoculation in early childhood.

Another group of infections occurs through the bites of insects, mosquitoes and ticks are responsible for a number of protozoan, helminthic and viral infections Malaria is caused by a protozoan. Its incidence in the country was brought down considerably under the National Malaria Eradication Programme but in recent years it has reappeared in many areas of the country.

Filaria is a helminthic infection transmitted through the bite of mosquitoes. It causes fever and repeated attack may lead to elephantiasis Filariasis also occurs all over the country and a National Filaria Control Programme has been organized to eradicate this.

Mosquitoes transmit many viruses through their bite. Dengue occurs all over the country and is characterised by high fever, backache and joint pains lasting from 3-7 days There are many other viral infections, some mild and others severe, which are transmitted by mosquitoes to man.

Ticks also transmit infections to man through their bite Some are viral infections like Kyasanur Forest disease in Karnataka which is limited to a small forest area Ticks also transmit typhus fever and relapsing fever.

Plague is a bacterial disease and is transmitted through the bite of fleas. Sandflies spread the infectious agents of sand-fly fever, Kala-azar and oriental sore.

Rabies is a viral disease and is also fatal It occurs after bite of a mad dog or jackal or any other animal suffering from rabies infection This is also preventable if the patient, after the bite, reports to the hospital and undergoes a full course of injections for treatment

Many infections occur through direct contact. Venereal disease like gonorrhoea (bacterial) and syphilis (spirochaetal), trachoma (viral), scabies (mite), etc , occur due to contact infection Tetanus is a serious, often fatal disease which is caused by the toxins produced by a bacterium which gets into a wound through contamination by dirt or soil. Tetanus is entirely preventable if the person is given immunization in early childhood by giving tetanus toxoid inoculations or is protected by anti-tetanus serum soon after injury

Tuberculosis is a chronic disease caused by bacteria and this disease is extremely common which affects lungs, lymph nodes, bones, brain and intestines in different persons. Nearly 2 per cent of the population of this country suffers from tuberculosis It has been estimated that there are 8 million active cases of this disease and of these nearly 2 million are infectious because they cough out a large number of tubercle bacilli in their sputum, thus creating a situation where healthy persons inhale these bacteria in air and get the disease. BCG vaccination in childhood can provide protection against tuberculosis.

Leprosy is widely prevalent in the country. Over 3 million persons are suffering from this disease and nearly 25 per cent of them are infectious for healthy persons. The disease is more prevalent in southern and eastern parts of India Nearly 372 million of our population is exposed to the risk of getting this disease. Control measures for leprosy are difficult. Cases have to be detected, treated and properly rehabilitated

National programmes to eradicate and control some of the major communicable diseases have been in operation. The National Smallpox Eradication Programme has succeeded and smallpox does not occur in the country any more although strict watch will have to be kept for the next few years. The National Malaria Eradication Programme very nearly succeeded but for some recent set backs

The National Leprosy Control Programme has made headway and large number of service and treatment centres have been set up for this purpose. The National Tuberculosis Control Programme has an integrated approach including BCG vaccination, detection and treatment of cases and isolation of tubercular persons through education, proper housing and sanitorium treatment.

The National Cholera Control Programme is based on improvement in environmental sanitation, availability of safe drinking water and proper disposal of human excreta Cholera vaccine is available but offers protection for a short period only. The National Filaria Programme is based on reduction of the mosquito population by antilarval measures and by reducing the reservoir of infection by treatment of affected persons

Trachoma is responsible for severe diseases of the eye and is being controlled by providing ointment containing antibiotics through the rural health services.

Venereal diseases are more of a social problem and require education and social efforts for their control in the country.

TEST ITEMS

1. How is the body generally protected from the attack of parasites and micro-organisms ?
2. Mention some of the bacterial, viral, protozoal and helminthic diseases which affect man through the gastro-intestinal tract How can they be prevented ?
3. Write a short note on diseases caused by bites.
4. Write a short note on national disease control and eradication programmes.

CHAPTER **38**

Nutritional Disorders of Man

1. Proteins, fats, carbohydrates, minerals and vitamins are all essential for health.
2. Children, especially infants, are more adversely affected by malnutrition than adults.
3. Vitamins are required in very minute amounts.
4. Over-eating can also produce diseases.

ADEQUATE nutrition is essential for maintaining a healthy state of the human body. Balanced requirements of calories, proteins, carbohydrates, fats, vitamins, minerals and trace elements for the proper growth and maintenance of human body are indeed well known. It is an unfortunate fact that a vast majority of the people of the world are very poor and they are unable to receive proper or balanced nutrition. It has been estimated that over one-third of world's population receives less than 2,000 calories per head per day Deficiency of one or the other essential requirements in food leads to poor health, an increased susceptibility to diseases and a reduction in the life span.

Quantitative deficiency of food leads to under-nutrition and may lead to starvation. This arises at the time of large scale famines when there is not enough food to eat. Among individuals, under-nutrition or starvation may be seen in severe diseases of the digestive system which prevents intake or absorption of food and also among patients with severe infections of liver or kidney failure when normal metabolism becomes disturbed.

Inadequate diet results in the loss of weight and a person is considered undergoing starvation if the body weight is reduced to 75 per cent or more of the normal.

During times of famine, a patient's desire for food is not a guide to what he can digest. Small amounts of skimmed milk given as frequent feeds is the best way of making them recover.

Qualitative deficiencies also occur when food is deficient in the essential nutrients, but they may also be due to wrong food habits.

PROTEIN CALORIE MALNUTRITION

Protein calorie malnutrition (PCM) can cause several disorders. In the majority of the children, PCM leads to their remaining underweight and they are susceptible to infections of respiratory and gastro-intestinal systems In some children, it may cause dwarfing with low weight and short stature. Such children are also more susceptible to infections than the normal ones

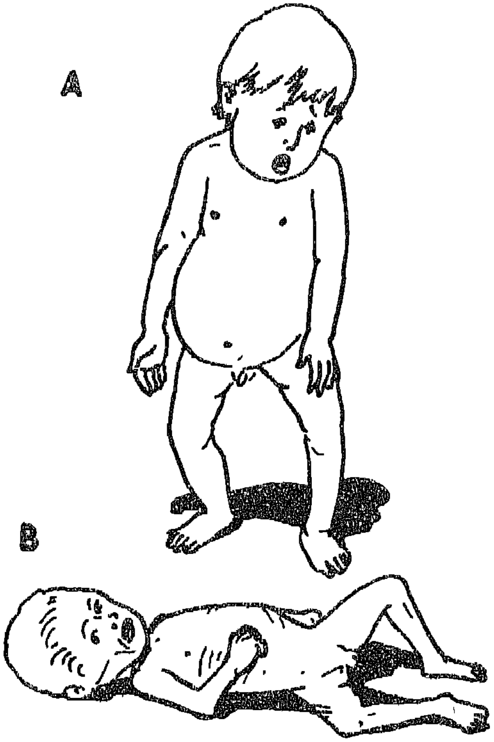

Fig 38 1. Infants suffering from (A) Kwashiorkor and (B) Marasmus

Marasmus (Fig. 38.1) is severe wasting disease of childhood due to grossly inadequate diet seen among infants of one year of age. Early and abrupt weaning due to poverty, subsequent feeding with diluted milk, repeated infections lead to growth retardation and wasting of muscles reducing the child to skin and bones.

Kwashiorkor due to PCM occurs among children of 1—4 years age. After weaning they are able to get a diet mainly consisting of carbohydrate with only a low protein content. Infections like those of the gastro-intestinal tract and measles may contribute to precipitate the disease. A child suffering from Kwashiorkor shows swelling of feet, wasting of muscles and changes in hair. Mental changes, skin. changes, markedly enlarged liver and anaemia are also seen among such children.

About one per cent of pre school children in India suffer from kwashiorkor; marasmus is twice more common than this disease Kwashiorkor is entirely preventable through intake of adequate diet and education of parents about dietary habits.

MINERAL DEFICIENCY DISEASES

Many elements occur in the body which are essential for metabolism and physiological functions. They include sodium, chlorine. calcium, sulphur, iron, iodine, fluorine and zinc

CALCIUM

Milk is a rich source for calcium and half a litre cow's milk contains 0.6 gm of calcium Vegetables, cereal grains and drinking water also provide calcium to human beings. Increased demands for calcium are made during pregnancy and lactation. Inadequate intake of vitamin D leads to disturbed metabolism of calcium.

IODINE

Iodine is widely distributed in food and water It is an essential element in the functioning of the thyroid gland and its hormones Lack of iodine results in enlargement of the thyroid which is known as *goitre*. In India about 9 million people are affected and another 45 million face the risk of getting goitre.

Goitre occurs extensively in the sub-Himalayan region from Kashmir to Arunachal and the highest prevalence has been noted among young boys and girls Goitre leads to high incidence of *cretinism* which is characterised by physical and mental changes and disorders of the nervous system. One of the successful ways to prevent goitre is to add one part of iodine to 10-20 thousand parts of common salt

FLUORINE

The commonest source of fluorine are drinking water (specially hard water), sea fish and tea Fluorine is present in human bones. There is a greater incidence of teeth decay (dental caries) if the amount of fluorine in drinking water is less than 0.5 part per million parts.

IRON AND OTHER ELEMENTS

Iron is present in adequate amounts in meat, fruits and green leafy vegetables. Formation of blood cells in the bone marrow requires iron, traces of copper and cobalt, vitamins B_{12}, folic acid, ascorbic acid, pyridoxine and proteins. Deficiency of iron causes *anaemia*.

Depletion of sodium and potassium are associated with disturbances of water and electrolyte metabolism of the body. Traces of copper, magnesium and cobalt are essential for formation of normal red blood cells.

VITAMIN DEFICIENCY

Human body requires vitamins for its normal metabolism. It cannot synthesise them in adequate quantities for this purpose. An external source through diet, therefore, becomes essential Deficiencies of five major vitamins are known to occur in man, viz., vitamins A, B-complex, C, D and K. Among these vitamins A, D and K are fat soluble. Vitamins C and B complex are water soluble. Fat soluble vitamins are not available if there is no fat in the diet. Anti-vitamins are known to occur in raw fish and certain synthetic drugs. Some vitamins are present in food as precursors like carotene for vitamin A. The bacteria in the intestine synthesise certain vitamins like vitamin B-complex and vitamin K but they also reduce the amount of other vitamins Vitamin D may not be required if skin is adequately exposed to the sun.

Vitamin A is found in milk, liver, fish and is widely distributed in plants and fruits. Vitamin A deficiency leads to *night blindness*—involvement of conjunctiva which becomes dry, thickened and pigmented, later leading to ulcers of the cornea which may cause total blindness. These diseases are entirely preventable if adequate amounts of vitamin A are available in the diet, viz., 300 to 600 mg per day for infants and children, 750 mg for adults and 1200 mg for lactating mothers.

Vitamin D deficiency causes *rickets* in infant and children, and *osteomalacia* in adults. Both these conditions are frequently reported in India. Deficiency of vitamin D may occur not only because of inadequate amounts in the diet, but also due to poor housing and inadequate exposure to sunlight, which is plentiful in India. The vitamin D deficiency is usually associated with inadequate intake of calcium.

Vitamin K is essential for the formation of prothrombin which is required for the normal clotting of blood. Vitamin K is present in dark green vegetables like spinach. Normally occurring bacteria in the intestine can also synthesise vitamin K. Vitamin K is required in the treatment of disorders of clotting of blood.

Vitamin C or ascorbic acid is present in citrus fruits and vegetables Deficiency of vitamin C in the diet leads to *scurvy* with bleeding gums and haemorrhages in the skin Scurvy used to occur among sailors on long voyages and is not seen now-a-days Other minor ailments like delay in healing of wounds, loss of appetite, tender joints have also been listed as caused by relatively minor deficiency of vitamin C. Total requirement of Vitamin C for an adult is 30 mg daily It has been claimed that ascorbic acid in large doses can help overcome common cold.

Vitamin B-complex consists of a group of water-soluble vitamins Though not related chemically, they are grouped together because they are essentially parts of specific enzyme systems on which cell metabolism depends

Thiamine (vitamin B_1) deficiency causes *beri-beri* which leads to swelling of the legs, the face and the involvement of peripheral nerves

Niacin is an essential part of two important pyrimidine nucleotides. Its deficiency causes *pellagra* among people who live mainly on maize. Sunburn-like patches on limbs and disturbances of nervous system occur in this disease.

Riboflavin is required in the diet. Its deficiency causes small ulcers in the mouth.

Vitamin B_6 consists of three closely related chemical compounds and acts as a co-enzyme. Vitamin B_6 deficiency is rare in man.

Vitamin B_{12} is found in foodstuffs of animal origin and in microorganisms—bacteria and moulds (fungi)—and 2 mg of this is required per day The body can store this vitamin and the effects of the deficiency are, therefore, seen much later Vitamin B_{12} is essential for the formation of blood. Its deficiency causes anaemia and degeneration in the spinal cord.

FOLIC ACID

This is found in dark green vegetables liver and the kidney Other green vegetables pulses, nuts and some sea foods are also good sources of folic acid Deficiency of folic acid causes anaemia and atrophy in parts of the gastro intestinal tract

It should be noted that the deficiency of an essential nutritional requirement at first leads to adaptation by the body to the low intake for instance, by lowering the excretion through urine. In the second stage, biochemical changes occur but no disease is noticeable In the third stage, the disease manifests itself.

OVER-EATING

Obesity is the abnormal accumulation of fat throughout the body. About 10-15 per cent of adolescents in affluent countries are over-weight and over 90 per cent of them are over-weight due to over-eating. Genetic. environmental, hormonal and metabolic factors are also responsible for obesity Affected persons are prone to suffer from diseases of cardiovascular system Life expectancy is lowered. A balanced adequate diet and physical exercise can prevent the condition.

Vitamin A in excess amounts can cause temporary headache, nausea and vomiting Excess of vitamin D can cause increase amounts of calcium in blood. vomiting and drowsiness.

Excess fluorine in drinking water causes chronic fluorine poisoning *Fluorosis* is found in some parts of Andhra Pradesh, Punjab and Karnataka. Cases have also been reported from Tamil Nadu, Haryana, Rajasthan, Uttar Pradesh and Delhi. Preventive measures require supply of drinking water free from excess fluoride. Special filtration methods have been devised which can remove excess fluoride from drinking water.

LATHYRISM

It occurs due to consumption of large quantities of *Lathyrus sativus* (*Khesari dal*). Diet containing over 30 per cent of *L. sativus* taken for more than six months may cause the disease as shown by the paralysis of lower limbs. The disease occurs in certain parts of Madhya Pradesh, Uttar Pradesh and Bihar

TEST ITEMS

1. Write a short note on protein calorie malnutrition (PCM).
2. Write short notes on the daily requirements of (i) Calcium, (ii) Iron and (iii) Iodine in human diet. How would you prevent deficiency of each ?
3. Give the sources and deficiency diseases of the following :
   (i) Fluorine, (ii) Vitamin A, (iii) Vitamin C, (iv) Folic Acid, (v) Vitamin B_{12}, (vi) Vitamin D.
4. What are (a) Goitre and (b) Lathyrism ?

UNIT—7

MAN AND HIS ENVIRONMENT

CHAPTER 39

Ecosystem

1. The relationship between the living community and the physical environment is expressed by the term ecosystem.
2. There are four major ecosystems on earth · marine, fresh-water, forest and grassland.
3. Different living forms inhabit different ecosystems.
4. Physical factors on land are more varied than those in water.
5. A forest may include several small ecosystems.
6. Man is the only animal who has tremendous influence on his own ecosystem.

A COMMUNITY exists in an abiotic environment. The relationship between a biotic community and an abiotic environment is expressed by the term *ecosystem*. A pond, a meadow, a forest—all are examples of ecoystems; even a small aquarium represents an ecosystem.

STRUCTURAL COMPONENTS OF AN ECOSYSTEM

An ecosystem consists of a non-living environment and a living biological community.

The non-living environment of the ecosystem includes the basic organic and inorganic components of the physical environment like water, carbon dioxide, oxygen, nitrogen, phosphorus and other elements.

The living community includes *producers* (autotrophs), *consumers* (heterotrophs) and *decomposers* (saprotrophs).

The biotic community and abiotic environment are interdependent. There is a network of relationship—a system of give-and-take between the two. The abiotic substances supply nutrients to the autotrophic plants. The latter produce food from these basic nutrients and sunlight. The animals are unable to synthesise their own food. They are heterotrophs. They depend upon plants directly or indirectly for their food. The wastes and dead bodies of plants and animals are acted upon by the decomposers. The latter convert them into simple organic and inorganic substances and return them to the soil. Thus, there is a cyclic exchange of materials between the living community and the abiotic environment.

MAJOR ECOSYSTEMS OF THE WORLD (BIOMES)

Natural ecological groupings of plants and animals are called *biomes*. They are produced by the interaction of regional climates with regional biota and substrate. The biome is the largest unit of land community which it is convenient to recognise.

As the living organisms are found everywhere, a fresh water pond, a lake, a river, an estuary, the sea, a desert, a forest, a grassland a coral reef, a kitchen garden, a laboratory culture are examples of various ecosystems or biomes Thus, a biome may be very small such as a laboratory culture or something very large like the sea or desert.

Usually the living organisms of the world are classified as *aquatic* and *terrestrial.*

A complete classification of the biomes is :

Aquatic

1. *Marine*
   (i) Seas
   (ii) Sea shores
   (iii) Estuaries
2. *Fresh water*
   (i) Streams and rivers
   (ii) Ponds and Lakes
   (iii) Marshes and Swamps

Terrestrial

1. *Forest*
   (i) Tropical
   (ii) Temperate
   (iii) Taiga
2. *Grasslands*
   (i) Tropical
   (ii) Temperate
3. *Desert*
4. *Tundra*

AQUATIC BIOMES

Water is one of the most indispensable necessities of life and is available in plenty in the ocean, large lakes, rivers and ponds Ecologically important factors which govern the aquatic life are salinity, light, temperature, tides, waves, water currents, pressure and oxygen content.

The aquatic life falls into three categories. *plankton*, *nekton* and *benthos* Passively floating or drifting organisms are collectively termed as plankton. A plankton is composed of mostly microscopic plants (phytoplankton) and animals (zooplankton) The swimmers of the ocean constitute the nekton, benthos include the bottom dwellers.

Marine. The oceans constitute nearly 70 per cent of the earth's surface and provide over 300 times the living space as compared to land. The sea offers unusual stability in temperature, salinity and gaseous content The temperature of the surface water varies from 32°C in the tropics to —2°C in some polar regions The average salt content of sea is 3.5 per cent (NaCl is 2.7 per cent).

Sea The upper position of the oceanic region through which light effectively penetrates is the *euphotic* or *photic* zone The region of the ocean below the *euphotic* zone (below 200 metres or 600 feet nearly) is termed the *benthal* or *benthos* zone It is also known as *aphotic* zone This zone is completely free of photosynthetic organisms Thus a different set of environment and conditions prevail in each one of the ocean zones and each zone has its own peculiar life-forms Planktonic organisms include algae, diatoms, protozoans, small crustaceans, their eggs and larvae. Nektonic types are animals such as fishes, squids, turtles, seals, dolphins and whales which are capable of changing stations at will Among the benthoic forms may be mentioned the crawling, creeping and attached organisms such as starfishes, brittle stars, lobsters, sea cucumbers, sea anemones, corals and many others

Sea Shore The sea shore organisms live under variable physical conditions They are constantly under the impact of waves Most of them are covered and exposed twice daily by the rise and fall of the tides. Against all these odds, the sea shore is one of the most fertile habitats of the world.

Estuary The estuary may be either a river mouth or coastal bay. The tidal action provides an important regulatory factor.

Fresh Water Fresh water habitats occupy relatively a small portion of earth's surface Fresh water habitats may consist of *lentic* or standing water (lake, pond, swamp, bog) and *lotic* (streams, rivers) or running waters. The limiting factors that are likely to affect the organisms are temperature, transparency of water current and low concentration of respiratory gases which show much greater variation as compared to marine habitat

Streams and Rivers Two major zones are recognised here, the *rapid* zone and the *pool* zone. The rapid zone consists of shallow waters where the velocity of current is great enough to keep the bottom clear of silt and other loose materials. Forms which become firmly attached or cling to a firm substratum (e g. filamentous algae) or which are strong swimmers (e g. fishes) are found in this zone. In the pool zone water is deep and the velocity of water current is reduced. Silt and other loose materials tend to settle at the bottom in this zone.

Ponds and Lakes On the basis of depth and type of vegetation, three zones can be recognised here, viz., *littoral, limnetic* and *profundal.* The littoral zone is the shallow water region adjacent to the shore where light penetrates to the bottom This is usually occupied by rooted plants. The limnetic zone extends from the superficial part of the open water zone to the depth of effective light penetration The organisms associated with this zone are protozoans (ciliates and flagellates), rotifers, small crustaceans, insects and their larvae, algae, etc The profundal zone is the deep water part of the open water beyond the depth of effective light penetration. The animals of this zone include snails, mussels, prawns, crabs and worms.

Marshes and Swamps Marshes are low lying wet lands and are a fertile ecosystem suitable for ducks and other semiaquatic animals

Rows of marshy spots are found on either side of the roads and railway tracks in the countryside in India. Poorly drained lands that have standing water for several months of the year are full of disease carriers and pests.

Swamps are wet lands that support large trees and shrubs. They offer a wide variety of environmental conditions—both aquatic and semiaquatic. A rich variety of animals such as aquatic insects, reptiles and birds are common in such regions.

TERRESTRIAL BIOMES

The patterns of life on land are determined by the physical factors. The most important among these are radiant energy, moisture (rainfall) and duration of growing season. This has resulted in the development of a characteristic sequence of four rings of biomes over the land surface of each hemisphere of the globe: tropical rain forest, temperate deciduous forest, taiga or coniferous forest and tundra. But within a given zone of latitude, marked variations are encountered due to the intervention of seas and mountains

The regional variations in rainfall, within the tropics as well as in the temperate zone, give rise to a sequence of biomes in each. In order of decreasing rainfall, the sequence of biomes within the tropics runs from the evergreen rain forest to deciduous forest, grassland and desert.

In the mountains environment changes with altitude The horizontal sequence of biomes from the equator to poles is telescoped vertically from the base to the snow-capped peaks of the mountain (Fig 39 1) The tundra-like biome present at higher altitude is called *alpine*.

Tropical Evergreen Forest. These forests occur when rainfall is high and uniform This biome is found in India, the East Indies, the Congo Basin of Africa and the Amazon Basin of South America

The forest possesses a deep and dense vegetation. The evergreen broad leaves cover most of the trees which dominate the vegetation of the perennial plants. Little light can filter through the dense layers of the canopy of leaves to support the vegetation on the forest floor. As a result, no 'jungle' develops at the bottom layer Seasonal variations in vegetation are almost absent

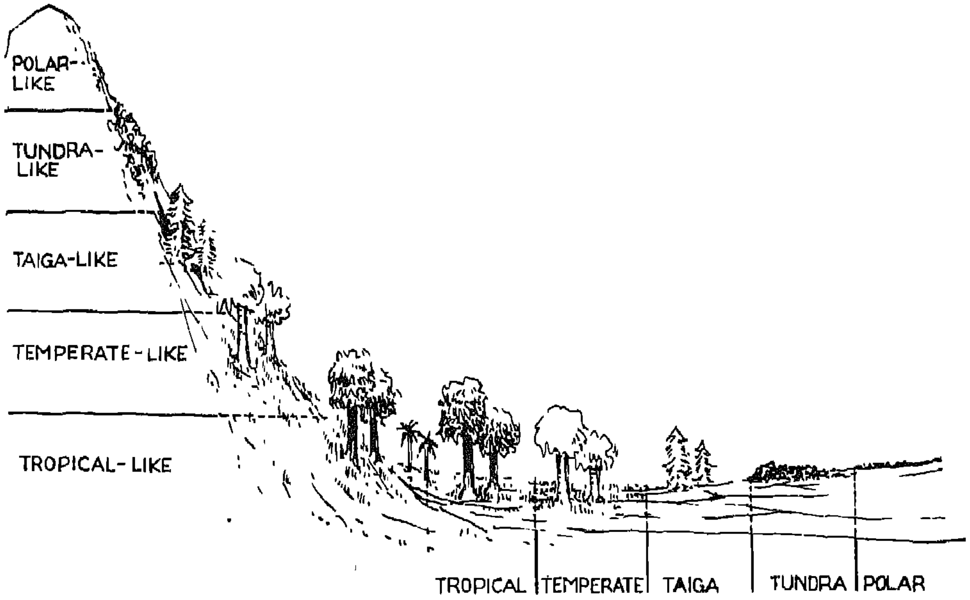

Fig 39 1 Horizontal and vertical sequence of biomes

In India, the evergreen forests nurture rubber timber-yielding trees like ebony, mahogany and rose wood, palms, plantains, bamboos, orchids and cycads, and the spice plants like cloves, cinamons and nutmegs

Each storey of the forest shelters different animals that may entirely differ from the one living above or below. More animals live on the richer upper levels than in the lower ones Birds are the dominant vertebrates of the upper levels.

Monkey, lemur and ant-eater are important arboreal mammals Elephant and tapir also inhabit the evergreen forest

The layer of fallen leaves and dead organic matter that cover the ground, under moist and warm climate, become congenial for the decomposers.

Tropical Deciduous Forest Tropical regions, experiencing dry and wet seasons, have forests of broad-leaved trees which shed their leaves during dry period. Such forests occur in the West Indies the eastern belt of Brazil, the southern tropical belt of Africa, the central plateau of India, Indo-China and the north-eastern projection of Australia.

These forests are less deep and dense than the evergreen ones The sunlight reaches the bottom and a very dense undergrowth of shrubs and herbs makes a 'jungle'. The climbers are few and the epiphytes and ferns are inconspicuous The forest floor vegetation includes annuals and perennials A few evergreen trees are found scattered Typical trees of the deciduous forests in India are teak, *mahul*, sal, *bigasal*, *semul*, *jamun*, *kusum*, *amla* and *palas*

Temperate Deciduous Forests. The areas of the temperate belt, with well-defined summer and winter and with a fairly abundant and well spaced rainfall, support this type of biome In the northern hemisphere it occurs in the eastern U S A , in western Europe and in Manchuria, south-eastern China, Korea and Japan In the southern hemisphere, similar forests occur in the eastern belt of Australia and in New Zealand.

The forest consists of a two-storied canopy. It reaches an average height of about 39 m. Below the lower canopy, stands a layer of shrubs On the bottom, there is a layer of moss and lichen

The broad-leaved deciduous trees shed their foliage in autumn, remain bare during the winter and bloom again in spring. The elms, maples, beeches, oak and hickory are the typical trees of the American forest

Insects are found at all levels in these forests. Birds and small mammals live in the tree cavities The shrub layer is inhabited by the spider, centipedes as well as reptiles, birds and different mammals.

Taiga. The taiga occurs mainly in the northern hemisphere It stretches across North America and Eurasia A similar one exists also in the southern hemisphere in the South Island of New Zealand

It is a region with a long and severe winter and mild summer with a short growing season. It is characterised by needle-leaved evergreen coniferous trees that reach about 10m in height. The vegetation is stratified into four layers the evergreen trees, short shrubs, low herbaceous plants and the bottom vegetation of moss and lichen The ground is covered with a thick layer of fallen needles and twigs The climate does not favour the decomposers

Usually, a single species of trees covers a large area The dominant species include spruce, fir, pine, poplar, birch and aspen.

In summer, many insects and insectivorous birds are seen in these forests The mammals found are the moose, beaver, muskrat and squirrel During the winter, insects hibernate birds migrate south ward and mammals become dormant or pass through a long winter sleep The reindeer and the caribou migrate from the arctic tundra to spend winter in this region

Grasslands. This biome occurs in the tropical and temperate zones with intermittent rainfall ranging from 25 to 100 cm during the year. The vegetation is dominated by grasses, legumes and composites The tropical grasslands occur in South America, Africa, India and Australia.

A thick cover of tall grasses with trees growing far apart characterises the Indian grassland, *savanna*. It gives shelter to some of the famous game animals of the world.

The temperate grasslands occur in both the hemispheres. In the northern hemisphere. they occur in North America, in eastern Europe and in northern and western Asia, and in the southern hemisphere, in Australia and South

Africa. These grasslands are called *prairies* and *plains* in North America, *steppes* in Eurasia and *veldt* in South Africa.

Deserts Deserts occupy one-fifth of the earth's surface and occur in regions with less than 25 cm of annual rainfall This rainfall is concentrated mainly in a few torrential downpours Deserts generally begin where the grasslands end.

The important deserts of the world are located in the northern hemisphere, the Great Western Desert (Death Valley) of the U S A , the Sahara Desert of Africa, the Gobi of Central Asia and the Arabian and the Thar deserts of Asia The deserts of the southern hemisphere are the Atacama and the Patagonian deserts in South America, the Kalahari in Africa and the Australian desert

Most of the plants are adapted to bloom and mature within a few available wet days in deserts. They include annuals (grass), thorny shrubs, succulents (cacti), mosses, lichens and blue-green algae. The plants are widely spaced and they include date-palms

The scarcity of the desert flora limits its fauna. The main problem is the scarcity of water.

The herbivores include mountain sheep, deer, kangaroo, rat and camel. The predators include foxes, hawks, owls small insectivorous birds, snakes (horned viper, rattlesnake, krait), lizards (gila monster, desert monitor) and horned toad.

Tundras The region lying south of the arctic ocean, and the polar ice cap and north of the taiga zone is called the arctic tundra The corresponding regions in the southern hemisphere is mostly covered by the antarctic ocean.

The tundra may be considered as an arctic desert. or a wet arctic grassland which remains frozen most of the time

The biome is completely treeless and the vegetation consists of lichens, a few species of mosses, herbaceous grasses, sedges and shrubs The plants are very low The leaves are small and hairy or their margins folded. The flowers are comparatively large, brilliantly coloured. and they bloom and mature quickly

The tundra vegetation supports a few species of insects, birds and mammals There are no amphibians or reptiles.

Polar Region. Beyond the tundra zone lies the permanently frozen soilless polar region that does not support any vegetation but is not without life. The polar region of the arctic is inhabited by the polar bear, walrus and the seal and that of the antarctic by the penguins These animals are not supported by the terrestrial ecosystem but are linked with the oceanic ecosystem.

ARTIFICIAL ECOSYSTEM

Agricultural lands gardens, parks vegetable gardens, etc., represent the man-made ecosystems A balanced aquarium is also an artificial ecosystem The manned spacecraft may be considered as an ecosystem The space capsule is a replica of earthly environment This ecosystem may last only for a limited number of days. For a longer journey, a self-contained spacecraft must include four basic components of an ecosystem, namely, producers, consumers, decomposers and abiotic substances.

TEST ITEMS

1. Complete the following sentences with suitable words.
   - (i) An ecosystem consists of four major components Producers, consumers decomposers and—--substances
   - (ii) ——are low lying wet lands.
   - (iii) Monkey and lemur are arboreal mammals of——forest. .
   - (iv) Beyond the tundra zone lies the permanently frozen and soilless—regions, that do not support any vegetation.
   - (v) A balanced aquarium is an——ecosystem
2. Define (i) Ecosystem, (ii) Biome, (iii) Zooplankton, (iv) Alpine, and (v) Tundra
3 Name (i) any two aquatic biomes, and (ii) any three terrestrial biomes
4 Show the similarities and differences between
   - (i) biotic and abiotic components of an ecosystem,
   - (ii) alpine and tundra,
   - (iii) pond and lake,
   - (iv) desert and tundra, and
   - (v) surface vegetation and bottom vegetation of a pond.

CHAPTER **40**

Biosphere

1. Living organisms depend on the earth for structural materials and on the sun for energy
2. Heat released by a living body cannot be used by a living system. So a perennial flow of radiant energy is needed, which initially comes from the sun
3. The materials from the earth circulate in cycles between the living system and the earth
4. Only the green plants are capable of binding the energy from the sun, others depend on the former for energy.
5. The captured energy flows through food cycle, food webs and trophic levels

THE world of living organisms together with the layers of water, air and soil on the surface of the earth is called the *biosphere*. The lithosphere, the hydrosphere and the atmosphere comprise, respectively, the solid, liquid and gaseous mantles of matter enveloping the earth.

The living world, comprising more than a million kinds of organisms, depends upon the *earth* for the necessary materials that enter into its composition and upon the *sun* for its constant need of energy to perform its vital activities It would be of profound interest to have a closer view of the *flow of energy* and the *cycles of materials*

FLOW OF ENERGY

The energy that sustains the world of life is the light energy coming from the sun which continuously releases an enormous amount of *radiant energy* Solar radiation is attenuated as it passes through the atmosphere and a part of it reaches the earth's surface.

SOLAR ENERGY ON EARTH

Some part of the energy that reaches the earth's surface is also reflected back Only a fraction of the incoming radiation strikes plants, most of which is reflected and lost as heat in the process of transpiration. Only a negligible amount of solar radiation striking the plants is fixed through photosynthesis. This light energy fixed in photosynthesis is about 0 1 per cent of the energy received from the sun by the earth, that is, about 4×10^{13} calories per second.

TRAPPING LIGHT ENERGY

No animal can utilise the sunlight for its living activities. The green plants possess chlorophyll This chlorophyll is capable of absorbing all the light waves except the green ones. During the process of photosynthesis, water and carbon dioxide are used to build up complex carbohydrates. The absorbed light energy is thus trapped as chemical energy. Thus, solar energy is introduced into the biosphere through photosynthesis. This is one of the most profound cosmic processes that transform the physical energy into chemical energy and links the non-living world with the living.

ENERGY PATHWAY

The pathway along which this energy flows can be studied in two ways:

1. We can study the food relationships between species and the community by way of food chains, food webs and trophic levels
2. We can also assess the energy flow in terms of number of organisms, their biomass and caloric content.

Food Chains

The green plants synthesise food during photosynthesis, taking raw materials from the earth and energy from the sun Thus the green plants are *producers* in the living world. The potential energy along with the materials of the food then is passed through the community, from the producers to the successive orders of *consumers* and at each stage it is released as heat We can get an idea of a pathway from this flow of energy by the study of what is known as a *food chain* A food chain is the representative of a *single energy pathway* For example, in the Gir Forest community, the grass is eaten by the deer which in turn is eaten by the lion (Fig 40.1) This energy flow can be represented in a food chain as·

Grass →	Deer →	Lion
(Producer)	(First-order consumer)	(Second-order consumer)

In land communities with large herbivores, food chains are often short and have usually two or three links.

In ponds with usually minute herbivores, the sequence could be.

Algae→Protozoa→Small aquatic insects→Large aquatic insects→Small fish→Large fish

In the ocean, it may be·

Phytoplankton → Zooplankton → Small fish →Large fish→Still larger fish.

Food Webs

Numerous food chains exist in a community. Many of these chains are interconnected by species which occur in more than one chain. These interconnected food chains establishing a network of species relationships constitute a *food web* (Fig 40.2) In the food web illustrated in the figure you can see a complex of numerous pathways along which the energy flows within a forest community

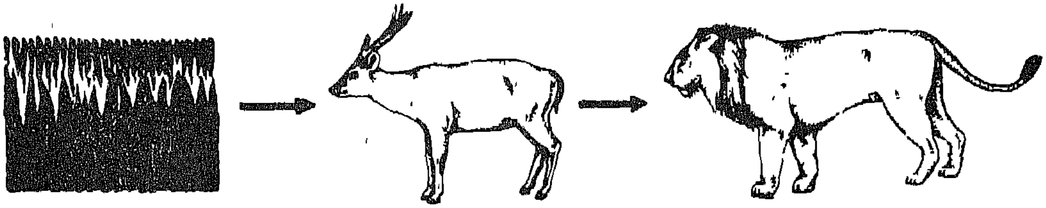

Fig 40 1. A simple food chain · grass→deer→lion

Trophic Levels

In a food chain, each link is known as a trophic level The plants are producers and constitute the first trophic level Herbivores or the first order consumers constitute the second trophic level and the carnivores that feed upon the herbivores constitute the third trophic level Large carnivores that feed upon small carnivores form the fourth trophic level If you compare the *number of organisms* living at each trophic level in a chain, then you can represent the chain by a *pyramid* of numbers The base of this pyramid is formed by producers and the apex by the last-order consumer.

The pyramid however is never so simple In nature, lion not only feeds on deer but also on the *chinkara*, wild boar, buffalo, sambar and the four horned antelope (Fig. 40.3).

The same ecosystem may support several such pyramids, each culminating in a different organism.

Amount of Energy Fixation

The amount and rate of energy fixation can be measured from the photosynthetic equation.

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{673\text{k.Cal}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

If the amount of one of the components of the above equation is known, then the other components of the equation can be estimated. The amount of energy fixation varies from about 0.2 per cent in aquatic ecosystems to 5 per cent in the more efficient agricultural ecosystems

During the transfer of energy through successive trophic levels in an ecosystem, there is a loss of energy all along the path No transfer is 100 per cent efficient. Lindemann in 1942 gave one of the most useful generalisations which is called 'the 10 per cent law' This law states that in nature only some fraction of the energy entering any population is available for transfer to the next population that feed upon the former The actual amount varies. In the grazing chain, about 10 per cent of the energy in the food eaten is turned into the biomass of the eater. For example, 100 kg of organic matter in grass will turn into 10 kg of flesh of a deer which in turn will form 1 kg of flesh of lion that feeds on the deer

THE CYCLE OF MATERIALS

The life on earth depends upon the availability of energy and also on the cycling of some elements and their compounds which plants and animals require for their normal growth and development. These substances are known as *biogenic nutrients*; they are of two types, the *macronutrients* and the *micronutrients*. The macronutrients include the elements and

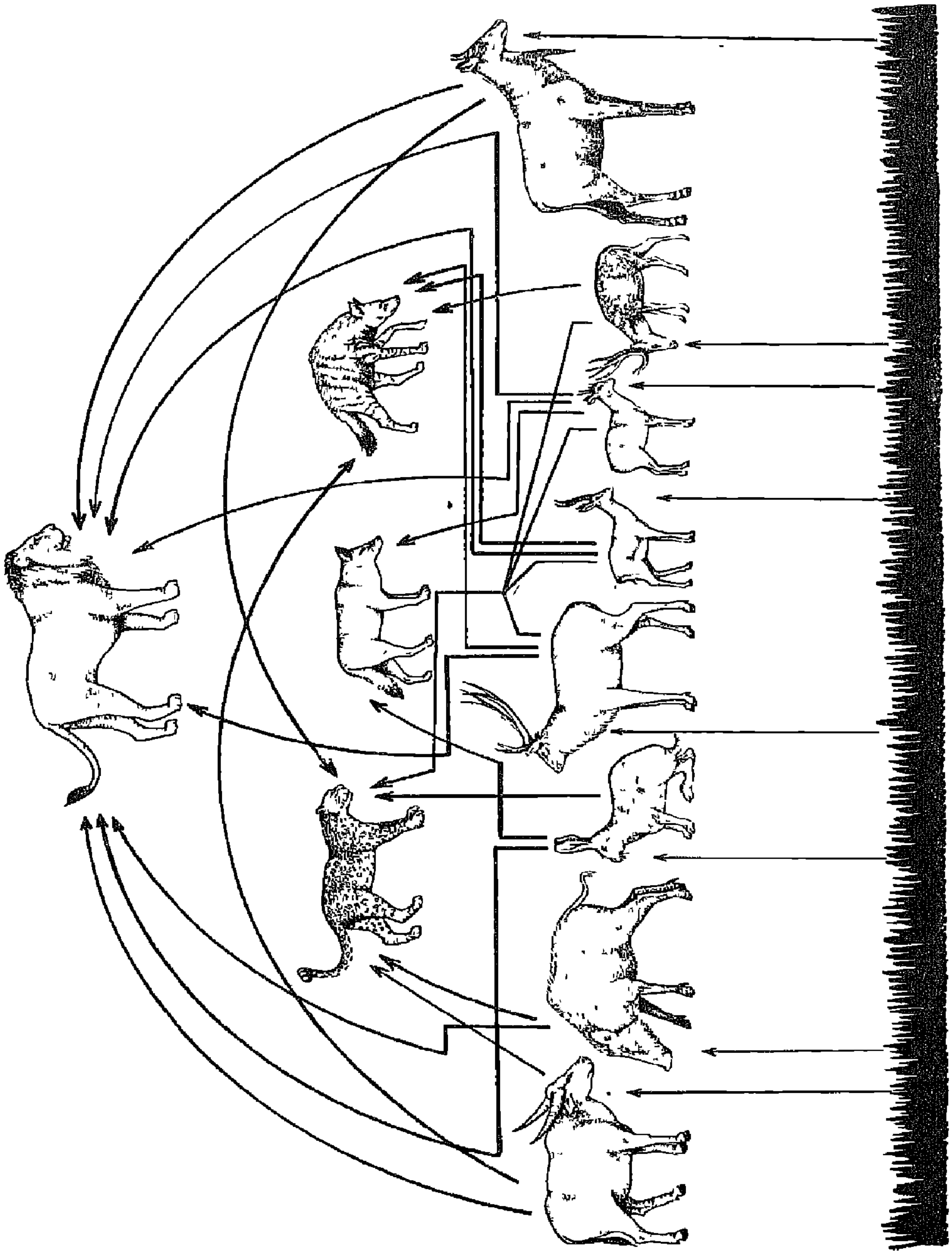

Fig 40.2 Food web in a hypothetical forest

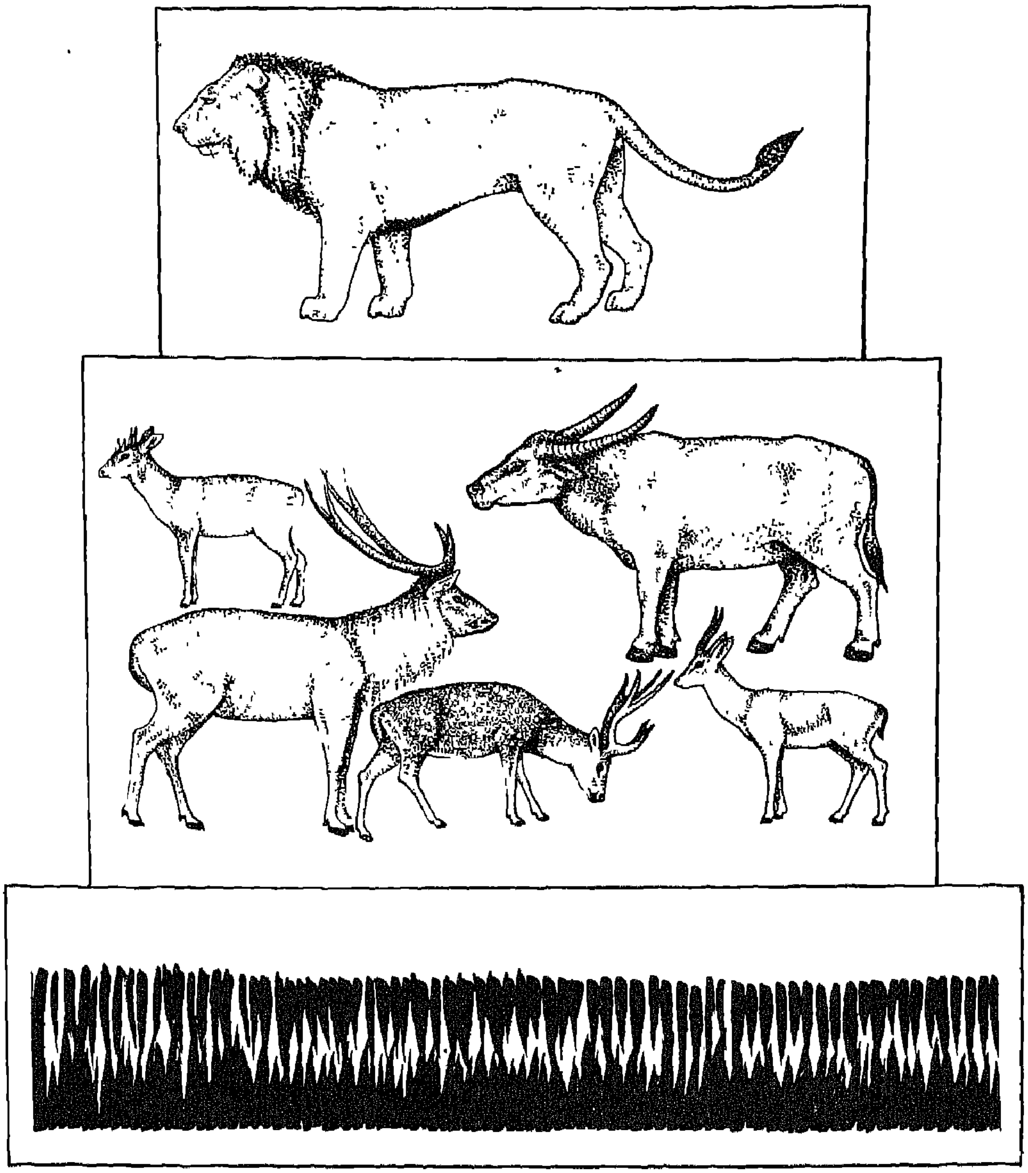

Fig. 40.3 The food-pyramid of lion.

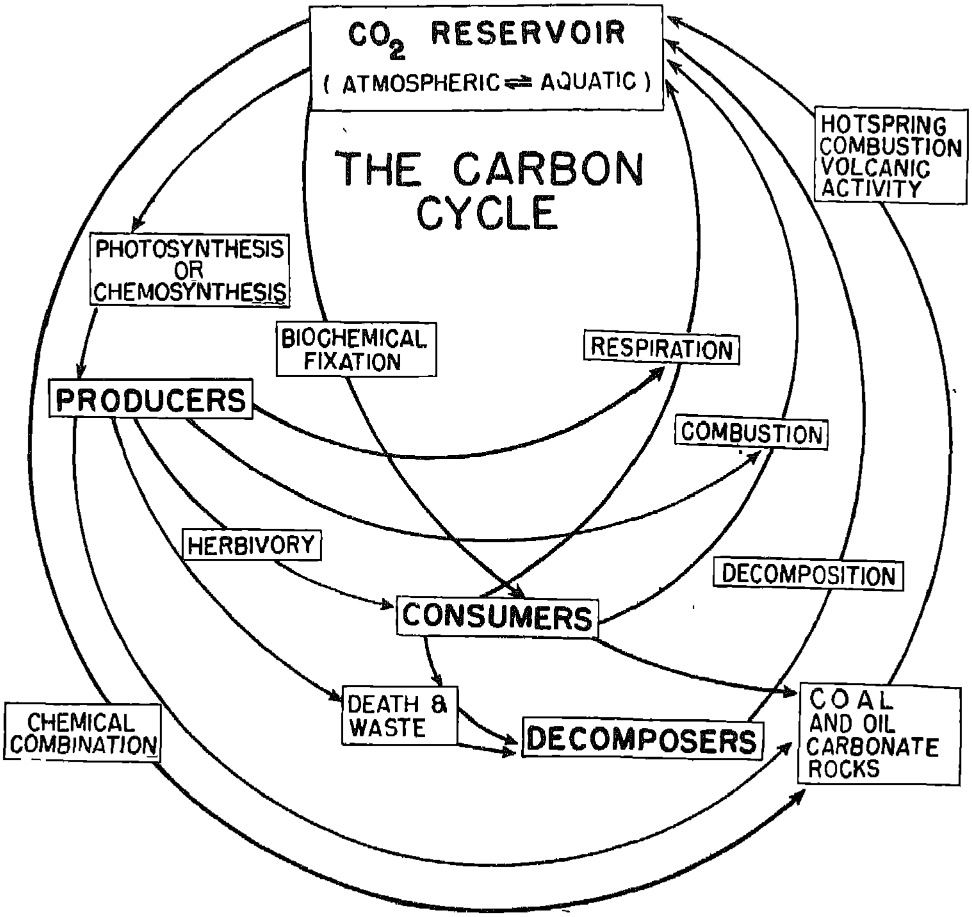

Fig 40 4 The carbon cycle.

their compounds which are required in relatively larger quantities—carbon, nitrogen, oxygen, potassium, calcium, magnesium phosphorus, etc. The micronutrients are also very essential but they are required in small amounts and include iron, zinc, copper, sodium, molybdenum, cobalt, strontium, borax, etc. Therefore, it is important to consider the movement of these nutrients in the ecosystem. These materials flow from non-living to the living and back to the non-living, in a more or less circular path. This cycle is known as *biogeo-chemical cycle.*

CARBON CYCLE

Carbon is the basic component of all organic compounds of which all living things are constructed Carbon is present in a variety of carbonates, fats, proteins and nucleic acid. The carbon cycle is essentially a perfect cycle in the sense that carbon is returned to the environment about as fast as it is removed The basic movement of carbon is from the atmospheric reservoir to producers, to consumers and then back to the atmosphere (Fig. 40 4) In atmosphere the concentration of carbon dioxide is about 0.03—0.04 per cent.

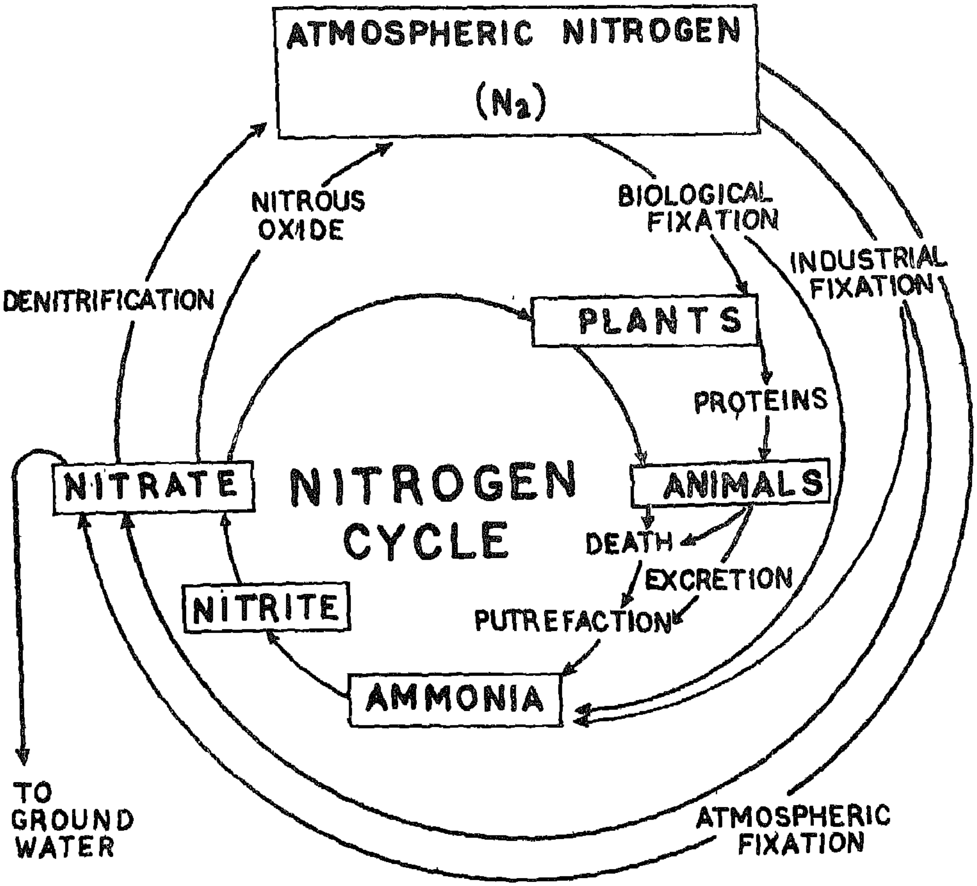

Fig 40 5. The nitrogen cycle.

OXYGEN CYCLE

Our ~~atmosphere~~ contains about 21 per cent oxygen It is also present dissolved in water Oxygen is given out as a byproduct of photosynthesis Plants and animals utilise oxygen in respiration and return it to the atmosphere and water in the form of carbon dioxide The carbon dioxide is utilised by green plants as an essential raw material for carbohydrate synthesis In this cycle oxygen is replenished and maintained in the ecosystem.

HYDROGEN CYCLE

The only source of hydrogen is the water molecule. In photosynthesis, water molecules are split into oxygen and hydrogen. Hydrogen enters into the composition of glucose molecules. Through glucose it moves into various organic components of the body During respiration the glucose molecules are broken down and the hydrogen atoms are oxidised to form water.

Carbon, oxygen and hydrogen cycles are

inseparably related to one another. All the three cycles involve producers, consumers and decomposers which keep these cycles combined into a single carbon-oxygen-hydrogen cycle This combined cycle may be called the *energy cycle* because it involves the flow of energy from the beginning to the end in the biosphere.

NITROGEN CYCLE

Nitrogen is an essential component of all proteins and nucleic acids which form a significant portion of living substances. The atmosphere is a rich store of nitrogen. Nitrogen is present in the atmosphere to the extent of about 78 per cent But in contrast to the carbon cycle, the atmospheric nitrogen is used only by a few simple organisms. The atmospheric nitrogen must be fixed into the form of inorganic substance (nitrate, nitrite) before it can be used by the green plants. Once the nitrogen is available in the form of these compounds in the soil, it is cycled and recycled through the ecosystems. It is seen that though the atmosphere is the ultimate source of nitrogen, its immediate source is the nitrogen occurring in inorganic forms in the soil (Fig. 40 5).

The nitrogen cycle involves five main steps: nitrogen fixation, nitrogen assimilation, ammonification, nitrification and denitrification.

CYCLES OF OTHER IONS

Some of the elements which enter into the structural components of living substances are found in the lithosphere, the rocky crust of the earth. The phosphorus and calcium cycles are described below.

Phosphorus. This is a constituent of nucleic acids, phospholipids, ATP, ADP and numerous phosphorylated compounds which play a vital role in the biological system Phosphorus enters into the biosphere as phosphate ions These phosphate ions are absorbed by plants through the root hairs and in course of time, become incorporated into different phosphate containing compounds This phosphate is transferred to consumers as organic phosphate. The waste, dead plants and animals are acted upon by the decomposers (fungi and bacteria) which return the phosphate ions to the soils.

Calcium. This is available as calcium compounds which are found in the rocks. Most of them being soluble are also found in water. Organisms procure dissolved calcium compound with the water they take in. The plants absorb calcium compounds from the soil and incorporate it into the living substance. Through food chains, the organic calcium compounds move to different animals. The decomposers release this calcium from the dead plants and animals and return it to the soil or water.

TEST ITEMS

1. Describe the flow of energy at the producer level and the consumer level.
2. What are the salient features of energy flow in the biosphere ?
3. Give a brief account of the flow of energy and the cycle of materials in the biosphere.
4. Describe the nitrogen cycle.

CHAPTER 41

Ecological Crisis

1. All living things depend on each other in the biological community.
2. Man himself is a part of this community
3. Man is the only animal who can change or destroy his environment.
4. This has caused an ecological imbalance which must be rectified.

You have already learnt that no living thing, or organism, can live by itself. All living things depend on other living things. When studying the food chain, for instance, you learnt that deer need grass to live, and a lion needs deer to live But the important thing to remember is that it is not just *some* living things which need *some* other living things. *All living things need all other living things* This is not always easy to understand, because the different forms of life do not always depend on each other directly; the dependence can be in indirect and complicated ways In other words, all the plants, animals, birds, fish, reptiles, insects, etc , are connected to each other in a complicated system in which they all depend, directly or indirectly, on each other. This big system is called the Biological Community, and since every part of it is dependent on all the other parts, then it follows that the whole community can survive only if every single part of it survives.

However, for a living thing to survive does not mean that it must just continue to multiply without any check. All forms of life, or species, as they are called, must exist only in a certain proportion, so that they can all survive. For instance, if there are too many lions they will kill all the deer altogether. On the other hand, if there are too many deer they will eat too much grass and there will not be grass enough for the other animals So some lions are needed to control the population of deer. This is how all species are connected with each other or interact with each other. They depend on each other to survive, and act as checks on each other The result of the whole process is a complete balance in nature. This balance is called the Ecological Balance, because ecology is the study of the connections between living things. Therefore, when we say that the biological community is healthy, we mean that it is in a state of ecological balance, i.e that all the species in it are surviving and surviving healthily.

The next step is to remember that every living thing also needs, around it, land, air and water. Obviously the deer cannot have grass to feed on if there is no fertile soil and no suitable water for the grass to grow. Land, air and water together are called the physical environment To sum it up, then, you could say that for living things to survive well in the world it is necessary that the biological community should interact healthily within itself, and also interact healthily with the physical environment around it.

The third, and most important factor to remember, is that man himself is a part of the biological community, and that if the community is not in a state of ecological balance, then man himself will suffer as much as any other animal in the community To give an example, if, owing to ecological imbalance, the number of birds is considerably reduced, then the number of insects will increase far too much, because birds eat insects and thus keep a check on them. And when insects multiply in this way, they will destroy man's crops, and the human population will starve

It is also obvious that man also needs a healthy physical environment, firstly because the biological community requires it and he requires the biological community, and secondly because he himself directly requires land, air and water to survive, as much as any other animal does. However, there is one big difference between man and the other species of the world. This is that man is the only animal which can actually *change* the biological community and the physical environment, in a very drastic way He destroys an entire species of animal by hunting it. He cuts down a whole area of forest till it becomes a desert He pollutes the air and water with industrial chemicals. Finally, since there is no other animal to keep a check on the population of man himself, the human population has increased so much that the survival of other forms of life is threatened Such a large amount of change and destruction means that the ecological balance is upset, and we have ecological imbalance instead of ecological balance

Ever since man appeared on earth he has been hunting, cutting wood and gathering food, but not to such a large extent as to cause an ecological imbalance. In the twentieth century, however, man's activities have begun to destroy and change the biological and physical environment in a very drastic way This is because of the following · (1) The population explosion As we have seen, an overpopulation of any species, including man, causes imbalance. Secondly, since there are too many people on the earth, more natural things are being destroyed in order to make room for human beings. (2) Man in the twentieth century has made technological and industrial strides which have made it much easier for man to exploit nature. He has machines for felling trees and drills for digging, and has used these to clear forest areas for industries, cities, dams and hydroelectric projects, pipelines, etc.

The result of such destruction has been such a severe ecological imbalance that we call it the Ecological Crisis As we have seen, the ecological crisis threatens the very survival of man himself. If the human species wants to survive we must try to restore the ecological balance, by preserving natural life, replanting forests, preventing pollution and checking our own population.

CRISIS IN THE BIOLOGICAL COMMUNITY

Let us now see in detail how man has

created a crisis in the biological community.

To begin with, man has by now destroyed 50 per cent of the world's forests He has cleared them for agriculture, for cities and industries, and for use as timber. This has happened all over the world, but it is particularly true of our own country. We have many types of forest in India; the pine forests of the Himalayas, the deciduous or leaf-shedding forests of the plains, the evergreen rain forests of the Western Ghats. The Government has decided that 30 per cent of India's land should be covered by forests. However, there has been, and continues to be, so much destruction of trees that by now only 19 per cent of our land is covered by forest and even this is rapidly becoming less. If you look around you when travel on highways, you will see that even ordinary trees along the road are always being cut and burnt.

Since trees and animals depend on each other, it is clear that the destruction of forests has affected the rest of the biological community. Many species of birds and animals cannot survive except in a forest. The forest is their *habitat*, or the natural surroundings in which they need to live. Animals like the tiger and panther have become much reduced in numbers because the forests they live in have been destroyed. Early in this century, there were about 50,000 tigers in India; there are now less than 2,000.

Man has also destroyed animals and birds by the more direct method of hunting. Hunting is often for mere 'sport', but it can also be out of material greed—tigers and panthers are killed for their skins, which are sold for large sums of money to make rugs, coats, etc. The Indian Rhino (Fig. 41.1) has been severely hunted for its horn, which is supposed to have medicinal properties. Other animals which are facing extinction are the lion (Fig 41.2), the Indian wild ass, the Kashmir stag and the musk deer. Among birds, the Great Indian Bustard, and the White-winged Wood Duck are in great danger of extinction. The Pink-headed Duck and Jerdon's Courser are already extinct.

The only mammal which has become extinct is the Indian Cheetah It has been completely hunted out of existence in this country. The ecological imbalance caused by the extinction of cheetah is as follows· When the cheetah was common in India, its main food was the blackbuck antelope. This meant that the population of blackbuck was kept in check, and did not overincrease. However, once the cheetah had been made extinct by hunting, the blackbuck population grew far too much, and they needed so much grass to feed that there was not enough grass left for the other wild animals and for our own domestic cattle, which we need for milk and other purposes. Again you can see that the final sufferer is man.

Another form of life which we destroy whenever we can is snakes A fear of snakes is common to all of us and when we see a snake, our first instinct is to kill it. This is quite irrational, when we consider that there are only four common dangerous snakes in India. At any rate, snakes are useful to us because they eat rats, and too many rats destroy foodgrains. At the present time roughly 25 per cent of our stored foodgrains are eaten by rats every year. You can see that this is an absurd situation in a country which is so short of food; more snakes would certainly help indirectly to save our food

Man has also interfered drastically with the *aquatic* community, i. e. with the plants, fish and crocodiles which live in water. He has polluted the fresh water of lakes and rivers Swamps and marshes, which form a habitat for many plants and small animals, have been filled with mud and turned into land. Crocodiles have been hunted so that their skin can be used to make handbags and shoes. At the present time all three species of crocodilians in India are in danger of extinction. With regard to crocodiles, aga-

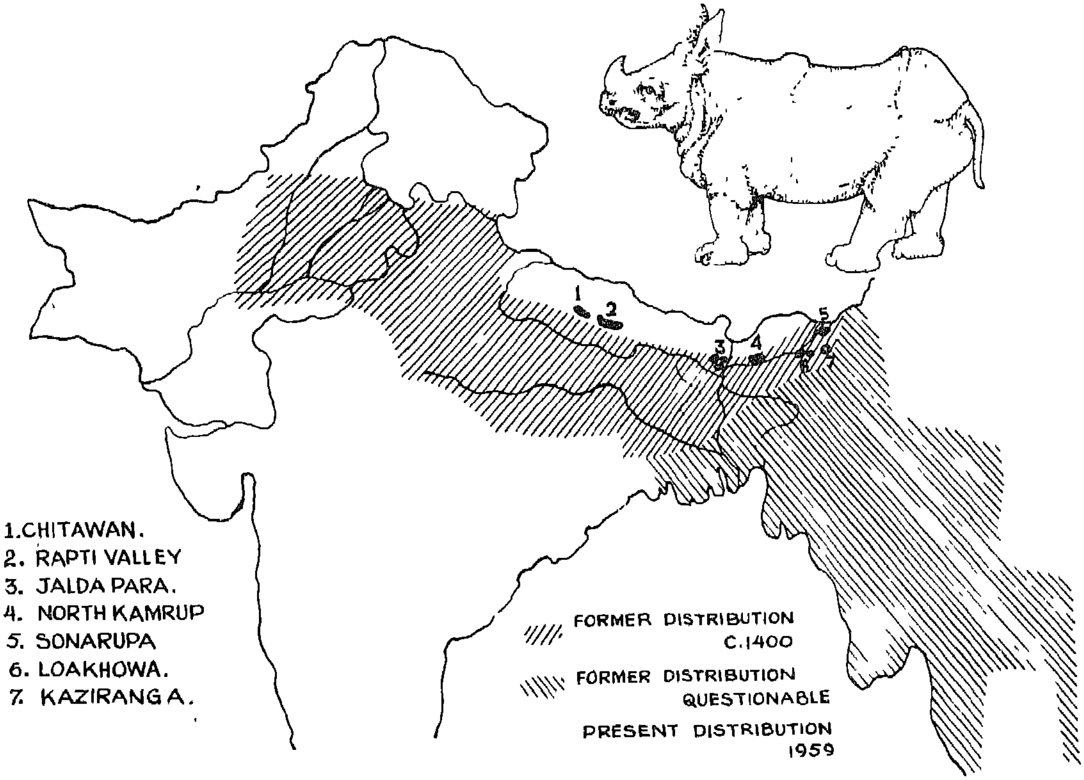

Fig 41 1 Past and present distribution of the Indian Rhino

in, we can see a telling example of the imbalance created artificially by man. Crocodiles habitually eat large species of fish, which in turn feed on the smaller species of fish which are eaten by us. Now that the crocodile population has become so much less, there is an over-population of the larger fish These are now consuming too many of the smaller fish, and once more, it is man who is left with less of suitable fish to eat.

Finally, as we have seen, man has allowed his own species to multiply unchecked. If our population continues to increase at this rate, then by the year A. D. 2000 there will be nearly seven billion people in the world. The rate of increase will then be 2 persons per second. This means 140,000 more persons, that is a new Mathura per day, 6.5 million more, or a new Bombay every month; and 70 million more, or a new France every year By A D 2,000, the population of India alone will be over 1,000 million

The increase of the human population has caused overcrowding and food shortage, and this is forcing man to encroach on forests and mountains, to look for more habitable and cultivable land, and for more space for grazing cattle. Since man constantly needs more food and more fuel, he kills more wildlife and cuts more trees As we have seen, these very activities in turn threaten his own survival, so the whole process is a kind of 'vicious circle' (The ways in which man exploits nature may bring him some short-term reward or profit, but they harm his own intersts in the *long run.*)

CRISIS IN THE PHYSICAL ENVIRONMENT

Let us now see in detail what man has done to the physical environment—which means land, water and air.

LAND

You must remind yourselves again that the biological community and the physical environment are inter-related, and a very vital, obvious example of this is the way in which land, or soil, is connected with trees. What man has done to the land is closely related to the destruction he has caused to forests and trees. It is clear that land is only good land when it is fertile, and land is only fertile when it is covered with, or surrounded by, trees. This is so for three reasons:

1. Trees act as wind-breakers They break the force and speed of a strong wind and prevent it from carrying away the fertile top soil In this way they prevent soil erosion by wind.
2. The roots of trees hold the soil firmly together. This means that rain or floods cannot wash the fertile soil away. In this way trees prevent erosion by water.
3. When trees die, they decompose into the material *humus*, which mingles with the top soil and makes it extremely rich in nutrients.

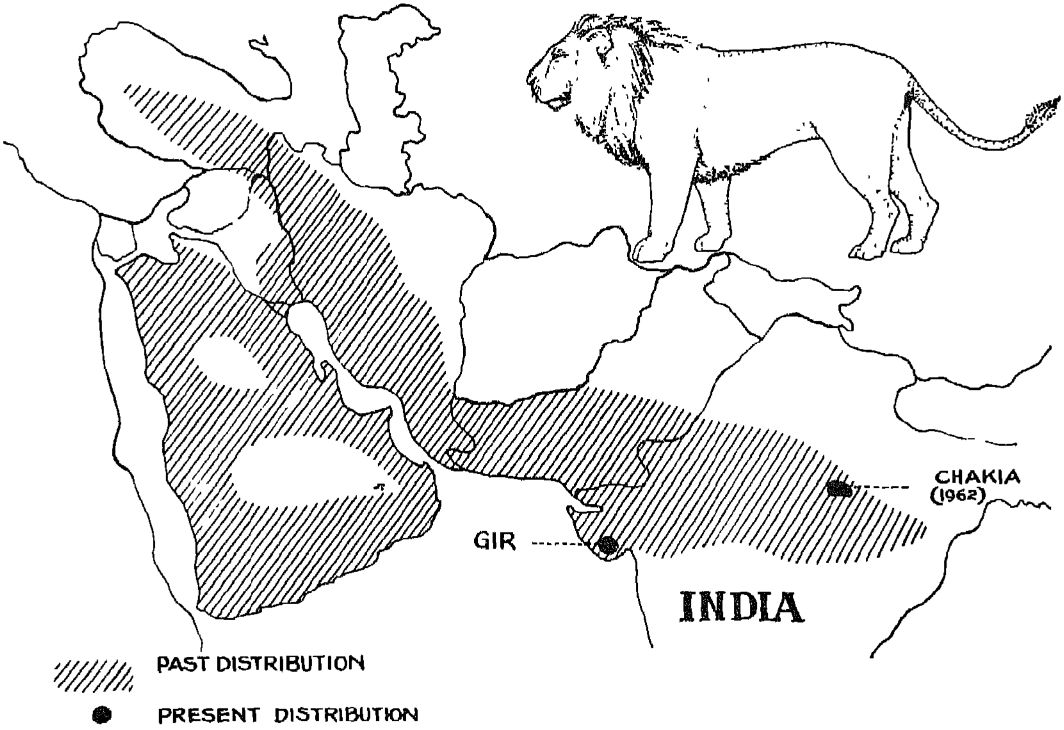

Fig 41 2 Past and present distribution of the Indian Lion

It is for all these reasons that trees are necessary for good land and soil Thus, by destroying huge tracts of forest, man has changed many areas of land which were once fertile, into barren areas unfit for cultivation, and finally into desert. The Thar desert for instance is entirely a man-made desert, at one time it was so thick with forest that Emperor Akbar went hunting there The process of spoiling land in this way is going on throughout the country because forests are cleared for agriculture, for making room for industrial and population growth, and trees are constantly cut down for firewood When you consider that it takes 900 years for a single inch of soil to form according to the natural process, you can appreciate the amount of waste that is caused by disturbing land.

WATFR

Water again is one of those things without which no life on earth, including man, could survive. We must therefore treat our water with as much care as we should treat soil. It is clear that we cannot actually *destroy* water, the way in which we can, for instance, destroy a tree. Because in some form, or other all the water which has ever existed on earth will continue to do so, on the earth or in the atmosphere—either as plain water, as clouds, steam or ice. But in spite of this we have managed to create a 'water shortage' for ourselves. Let us see how.

It will now be no surprise for you to learn that the crisis in water is, again, connected with the crisis in forests. In a normal and healthy environment, as we have seen, there are plenty of trees and their roots hold the soil firmly together This means that when rain water falls on the soil it cannot flow away with the soil, but seeps gently underground. The water then remains underground (most of it in large cavities which are formed when trees die and their roots disintegrate) and during the dry months, it reappears on the surface of the land in the form of springs, lakes and rivers This means that we have a steady supply of water all the year round. On the other hand if there are no trees, then the following things happen

1. The water cannot seep underground so it remains on the land's surface and causes floods.
2. The water as well as the top soil are drained away.
3. There is no underground water, so we suffer from water shortage in the dry months.

In other words, forests *regulate the water cycle* Without them, we would have only floods at one time and drought at another If you look at a map of India you will see immediately that all the areas which have suffered heavily from drought and flood in recent years — Bihar, Rajasthan, Gujarat and Maharashtra — are areas which have hacked down their forests. Secondly, most of the lakes from which cities and villages get their water supply are in what is known as 'catchment areas'. These are lakes which are surrounded by hill slopes, If these hill slopes are not forested, then the rain washes the soil into the bottom of the lake. The lake is then silted up and has much less of a capacity to carry water. This has been happening in many of our catchment areas. The absence of adequate water in rivers and lakes also affects our hydro-electric plants and causes power shortages, and we all know what a drastic thing a power shortage is.

We also add to the water shortage' through the more direct method of pollution There are three types of water pollution

1. The first is the contamination from industrial wastes, and this is the most dangerous The contaminants range

from waste materials to industrial chemicals, and include the dumping of oil in the ocean by large ships.

2. Secondly, the sewage of big cities is often drained into rivers. As there is not much current in the rivers because of silting, this sewage promotes the growth of phytoplanktons. Their excessive growth depletes the oxygen in the water, because when they die their putrefaction consumes the oxygen content of the water. This reduction of oxygen and the presence of poisonous wastes affect the fish population and thus decrease one of our major sources of food.
3. Rivers, lakes and ponds are also used directly by people for bathing and washing. This contaminates the water with the germs of various diseases. Typhoid, cholera, dysentery and hepatitis are some of them.

AIR

The importance of clean air is obvious; in its absence we cannot survive more than a few minutes Another peculiarity about air is that we all use the same air; after all the air which you exhale is then inhaled by your friend No nation can build a boundary wall around its air, and in a way this has made the problem of air pollution more serious than that of water pollution Because polluted water will affect only a particular region, but polluted air may affect the entire world. Once again we need trees for fresh air, trees take in carbon dioxide and give out oxygen, which we need to breathe. The prime cause of air pollution is smoke from various sources. For the past two centuries, coal and other fuels have been burnt for heat and power. Smoke gets into the air from kitchens, factories, trains, automobiles and aeroplanes, as a result the air is contaminated with soot, carbon dioxide and carbon monoxide. In some places, chlorine, oxides of nitrogen, ammonia, vaporised benzene and oxides of sulphur are also present in air.

The tests of nuclear weapons are adding radioactive dusts to the air The presence of these substances is harmful to human health

It has now been discovered that there can be some very long-term effects of air pollution. For example, between 1860 and 1960, the carbon dioxide content in the air increased by 14 per cent Besides causing respiratory troubles, this gas will absorb more infra-red rays, which in turn will increase the earth's surface temperatures. If this increase of temperature continues, it will lead to the melting of polar ice caps and glaciers, resulting in the rise of the water level of the seas, and then in violent tidal waves.

Rodioactive substances and other chemical dusts fall on the earth with rain They may then pass into the food chain, i e. they may enter grass which is then eaten by deer, which are then eaten by lions and so forth. Such substances, then, become a serious health hazard for all living things.

NOISE POLLUTION

In addition to the disturbances in land, air and water, a new kind of disturbance has cropped up. This is called 'noise pollution'. It has become especially acute in urban areas, because of different kinds of sounds produced by machines which vary from a transistor radio to a jet plane. Constant exposure to this sound results in deafness, and also increases nervous tension, blood pressure and heart trouble. Such effects have been noticed particularly among factory workers who are exposed to constant noise from machines.

TEST ITEMS

1 What is ecological balance ?
2. Illustrates some way in which man is dependent on the biological community
3 List the ways in which man has upset the biological community
4 What are the different types of water pollution ?
5. How do we pollute our air ?

CHAPTER 42

Conservation of Natural Resources

1. There are renewable and non-renewable natural resources.
2. Conservation of these resources does not mean blind preservation but judicious use.
3. There are different techniques of conserving soil, water, forests and wildlife

THE things about which we studied in the last chapter—soil, air, water, flora and fauna—are called *natural resources.* They are renewable natural resources, in other words, they reproduce themselves in the natural process The cut trees grow again, soil forms again, and animals reproduce themselves, although this renewal, you must remember, *does not take place fast enough to avert the ecological crisis* We also depend on other types of natural resources, such as minerals, coal and oil, which are mined from the earth. They are non-renewable, i.e. once they are used up, they will be exhausted for ever.

In the last chapter we saw how man has brought havoc among the renewable natural resources. It is clear that if he wants to continue to survive on this planet he must now begin to *conserve* these resources rather than merely exploit them as he has been doing. But conservation does not mean blindly preserving the resources without using them We cannot, for instance, altogether stop cutting-down trees or using soil. But what we can do is to use the resources wisely and judiciously, without wasting them Also we must attempt, wherever possible, to replace them, e.g. replant trees and forests Let us see in detail how the different resources can be conserved.

CONSERVATION OF SOIL

There are two basic ways of conserving soil : Preventing soil erosion and preserving soil fertility.

PREVENTING SOIL EROSION

This requires that as few trees as possible should be cut down, and wherever possible, trees should be massively planted. In fields, there should be proper irrigation and drainage and binding so that the water which flows from the field should not carry the top soil with it. There should also be proper drainage on slopes Instead of being planted from top to bottom, the fields must be *terraced* in other words, they must be planted in layers round the hill, so that water does not drain away down the slope, and take the fertile top soil with it. Also, fields must not be allowed to lie fallow for too long to prevent wind erosion.

PRESERVING SOIL FERTILITY

Apart from ruining forests, there are other ways in which we allow soil to be eroded. These are mainly bad farming methods For instance, farmers often loosen the top soil for removing weeds and preparing seed beds They also leave agricultural fields fallow for a long time This means that the top soil is exposed and wind erosion can easily take place.

Sometimes, even when the soil is not eroded, we use bad farming methods which result in the soil to be less fertile and productive One of these bad farming methods is the growing of the same crops, e.g. rice and wheat, on the soil Because every crop uses different ingredients from the soil, and if the same ingredient is used, i e , if the same crop is grown, year after year, the soil becomes poor. The main crops use up the essential elements in the soil, but there are a few leguminous plants such as pulses, peas and beans which replenish the soil with nitrogen. These crops should be rotated so that all the ingredients in the soil remain in a state of healthy balance. We must not allow ourselves to forget that soil is a complex mixture of physical, chemical and biological materials, and all these materials need to be looked after.

Another obvious method of preserving soil fertility is the use of fertilisers, and in this the farmers can get the help of local and State agricultural departments

CONSERVATION OF WATER

With water also there are two main techniques of conservation · Maintaining the water cycle and preventing pollution.

MAINTAINING WATER CYCLE

We have seen that this yet again depends on the preservation and planting of forests It is particularly important to have a healthy forest cover around the catchment areas. Also swamps, marshes, lakes and ponds must be carefully guarded—such wetland areas must not be filled with mud and reclaimed as land.

PREVENTING POLLUTION

Industries must take care not to empty their industrial wastes direct into the nearest lake or river; the wastes must be filtered before being discharged into lakes or rivers. Ships and oil tankers must take care not to dump their oil into the oceans Cities must take care that their sewage does not pollute the surrounding water areas. To do this, they should use special sewage plants where the sewage is first putrified, so that water alone is released into the river or lakes.

CONSERVATION OF FORESTS

The conservation of forests is simple and obvious. To begin with, as little forest as possible should be cut down. We do need timber, but we must take care that there is no wastage of wood in the process of making timber. As things are, it has been calculated that two-thirds of a tree is wasted between the time it is cut and the time it is converted into a finished product. Sometimes the better part of the tree is cut into logs, leaving the rest to decay

In saw mills the logs are carelessly cut without getting the maximum quantity of timber out of them. It is obvious that these are extremely wasteful methods and they result in many more trees being cut than is necessary. Such practices should be stopped immediately.

Another practice in our country which ravages the forests is what is known as 'shifting cultivation' This means that peasants clear an area of forest and use the land for agriculture, and when the soil is exhausted they abandon the land and clear another piece of forest. Large tracts of forest have been whittled away in this way Instead of this practice, farmers should continue to cultivate the same piece of land, but they should use better farming methods (described earlier) which will ensure that the soil remains fertile and can be used again and again.

Very often, forests are destroyed simply for short-term convenience. It may be that for various reasons a factory wants to be located in a particular area where the only obstacle is a forest. In such cases the forest is usually cut down at once, so that the factory can be set up. But what should really happen is that the owners of the factory should recognise that the forest is precious and irreplacable, and they should locate the factory on a different site, even though it may cause some inconvenience

All over the world, and especially in India, we must make a very large-scale effort to re-afforest the land. You have studied the overwhelming reasons for which forests are vital to us. Re-afforestation of the land is one of the foremost tasks facing the country today

As we saw in the earlier chapters, if the forest is to remain healthy, then the whole system of life within it, i e. the birds, animals, reptiles and insects, must survive healthily. This brings us to the conservation of another important resource—wildlife.

CONSERVATION OF WILDLIFE

We saw earlier how many species of wildlife are either already extinct or on the way to extinction The first step towards conserving the remaining wildlife is to conserve the different habitats in which they live, e.g tropical forest, light jungle, pine forests, wetlands, swamps, scrub areas, grasslands, etc It is thus clear that the conservation of wildlife is tied up with the conservation of other resources.

The animals which are rare or endangered must be rigorously protected from being hunted They are hunted for two reasons either for mere sport, or because various parts of their bodies, the skin, horn, tusks, or meat, can be sold for a good price The first requirement is legislation, or proper laws which forbid such hunting, the second is vigorous protection of the animals by the Forest Departments. They should make sure that no poaching, or illegal hunting, is carried on The sale and export of such products as tiger and panther skins, rhino horn and elephant tusks is largely forbidden already, but rigorous control is required to make sure that no illegal trade or smuggling takes place.

The best way to ensure that both the habitat and animals are preserved is to form as many wildlife sanctuaries and national parks as possible. In the next chapter we will learn about some of them

NON-RENEWABLE NATURAL RESOURCES

So far we have been discussing renewable natural resources. Let us now come to the question of the non-renewable ones, such as minerals, coal and oil. In today's technology-based culture we use many of these resources for fuel and energy, and it is feared that they will soon be exhausted, at the rate we are using them. We have already faced a severe shortage of petroleum. The crisis in all these resources together is called the *energy crisis*.

With regard to the resources themselves, it is clear that we can do nothing except to use them as sparingly as possible. However, we are now attempting to harness and use other sources of power which will not be exhausted. These new sources include water power, wind force and solar energy. Till these attempts are successful, man will have to be very economical in his use of present-day sources of energy, i.e. non-renewable natural resources.

TEST ITEMS

1. What is the difference between renewable and non-renewable natural resources ?
2. What are the two main methods of water conservation ?
3. What is shifting cultivation ?
4. What are the reasons for which animals are hunted ?
5. How can we 'conserve' non-renewable resources ?

CHAPTER 43

Conservation of Nature : National and International Efforts

1. IUCN and WWF are world organisations concerned with conservation
2. The Indian Government is making efforts to conserve our environment and wildlife

THE things that you have learnt in the earlier chapter may appear to be rather alarming. It may seem that man's existence on this planet is gravely threatened, and to a large extent of course this is true However, people all over the world are now becoming aware of the ecological problems and the need to correct the situation. This awareness increased greatly in the late forties, among a group of scientists and biologists To study and advise various governments on ecological problems more closely they set up the International Union for Conservation of Nature and Natural Resources (IUCN) in 1948., This organisation is based in Switzerland The 10th General Assembly of IUCN was held in New Delhi in November 1969.

However, studying ecological problems and deciding what to do is not enough We also need the money to implement the necessary steps Therefore in 1962, a sister organisation to the IUCN, the World Wildlife Fund (WWF), was formed, with the black and white Giant Panda as its symbol.

The main work of the W.WF is to raise money for conservation and to publicise its importance and make people the world over aware of the need for conserving Nature The WWF now has branches in about 24 countries, including India It has spent over $20 million (about Rs 160 million) on 1,600 conservation projects in different countries These projects include, the breeding, in captivity, of rare species which are then released in the wild, the saving of wild and beautiful areas; the creation of national parks, and pressurising governments of different countries to pass laws which are necessary for conservation

The Indian branch, or National Appeal, of the WWF, has been functioning since 1969 It has supported many valuable projects in India, including projects on the rare Great Indian Bustard and the Nilgiri Tahr It has helped to set up the Madras Snake Park However by far the most important and impressive WWF project in India is Project Tiger, which has been undertaken jointly with the Indian Government It is a Rs 75 lakh project, aimed at preserving vast areas of forest all over the country so that the tiger can survive in India in its natural habitat

The Government of India is aware of the importance of conservation in India and is making several efforts to redeem the mistakes of the past. For instance, the Indian Board for Wildlife was established in 1952 From the 1st to 8th October every year, a Wildlife Week is observed throughout the country. We have legislation restricting hunting and tree felling, and no doubt pollution laws will soon follow. Our excellent laws, properly followed, should ensure that the position of our wildlife improves considerably The Wildlife (Protection) Act of 1972 was an important step forward The killing of many endangered species, including the lion, tiger, the Indian Rhino, the Swamp Deer and the Indian elephant is now banned The trade and export of tiger and panther skins, rhino horn, and snake and crocodile skins is now prohibited We now have to fight against people who do these things illegally

Re-afforestation and replanting of trees is being seriously undertaken in many parts of the country, including in cities like Bombay

We have several beautiful national parks and wildlife sanctuaries in the country The Corbett National Park in Uttar Pradesh and Kanha National Park in Madhya Pradesh are both refuges for the tiger The Gir Sanctuary in Gujarat harbours the lion, and Kaziranga in Assam is a heaven for the Indian Rhino. The Bharatpur Waterbird Sanctuary in Rajasthan is one of the most exquisite and beautiful in the world, and Mudumalai / Bandipur in the south have a large elephant population

However, all these efforts, admirable though they are, will be ineffective unless each one of us, as an intelligent citizen of this country and the world, recognises the magnitude of these problems, spreads the message, and does whatever is possible to correct the situation

TEST ITEMS

1. What is the function of the IUCN ? Da
2. Write a note on the World Wildlife Fund
3. Name some of India's endangered species
4. Name some wildlife products for which Indian animals are hunted
5. What are the major sanctuaries and national parks in our country ?